Impact Assessment Study on Common Chargers of Portable Devices

December 2019

Written by Ipsos and Trinomics, in collaboration with Fraunhofer FOKUS and Economisti Associati
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Executive summary

In June 2009, following a request from the European Commission, major producers of mobile telephones agreed to sign a Memorandum of Understanding (MoU) to harmonise chargers for data-enabled mobile phones sold in the EU. The ensuing years saw a significant reduction in the fragmentation of charging solutions, in particular the widespread adoption of the "common external power supply" (in accordance with the international standards developed based on the mandate from the Commission), and convergence of around three quarters of the market to USB micro-B connectors. The remainder of the market (essentially corresponding with Apple's iPhones) continued to rely on proprietary connectors (allowed under the terms of the MoU as long as adaptors were available on the market).

Ever since the MoU expired in 2014, the Commission has been trying to foster the adoption of a new voluntary agreement. However, to date, no solution that would be acceptable to both the industry and the Commission has been found.

About this study

The aim of this study is to provide input for the Commission impact assessment accompanying a new initiative to limit fragmentation of charging solutions for mobile phones and similar devices, while not hampering future technological evolution.

The study was carried out by Ipsos and Trinomics, with support from Fraunhofer FOKUS (on behalf of a consortium led by Economisti Associati). It is based on research and analysis undertaken between January and November 2019. It employed a mixed-method approach, combining two main tasks: first, defining the problem (including a market and technology analysis), and second, an assessment of the likely impacts of a set of policy options for a possible new initiative.

The sources of evidence include primary data (collected via a series of in-depth interviews with key stakeholders, a survey of a representative panel of consumers, and the Commission's Public Consultation) as well as secondary data (including statistics, market data, and literature on a wide range of relevant issues). Where possible, key impacts were estimated quantitatively based on a tailor-made dynamic model of the stock of chargers. Other impacts were assessed qualitatively.

The focus of the study was on chargers for mobile phones, and specifically on technical options to work towards a "common" charger and their likely social, environmental and economic impacts. Other issues (including the available policy and regulatory instruments, the possibility to extend the scope to other portable electronic devices, and the issue of decoupling - i.e. the unbundling of charger from phone sales) were also considered.

The current situation

In light of recent technological and other developments, the current situation regarding mobile phone chargers can be summarised as follows:

- Absence of any binding (voluntary or regulatory) requirements as regards the interoperability of chargers for either mobile phones or other portable electronic devices.

- A high but not universal degree of interoperability of different charging solutions, due to the fact that cables are almost always detachable from the external power supply (EPS), and that large parts of the market have adopted technologies (including connectors) based on USB specifications and standards.

- Potentially significant variations in charging performance between brands and devices, due to the wide range of fast charging solutions on the market, meaning that, even if the likelihood is high that any given modern EPS can be used to charge nearly all mobile phones that are currently on the market, it may not do so at the same speed.

- A market in constant evolution, with USB Type-C connectors expected to gradually replace legacy USB connectors at the phone end (within the next few years) as well as the EPS end (more slowly), and innovation in fast and wireless charging technology likely to continue at a rapid pace.

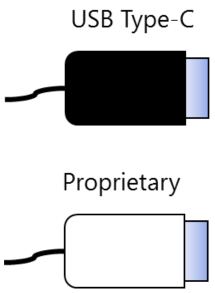
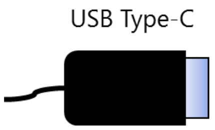
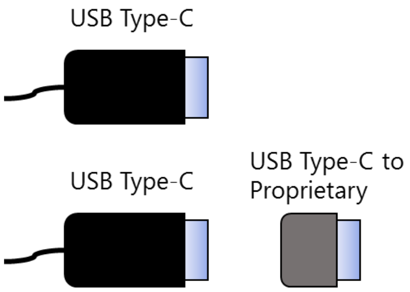
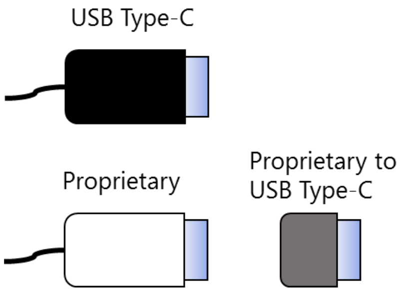
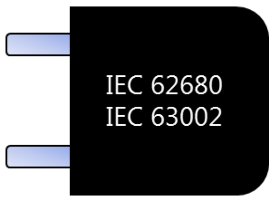
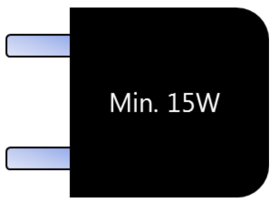
The available evidence points to two main problems that arise from this situation:

- Consumer inconvenience: Most mobile phone users (84% according to the consumer panel survey) have experienced problems related to their phone chargers in the last two years. Commonly cited problems (each experienced by between one third and half of respondents) were the inability to charge certain devices (as fast) with certain chargers; having too many chargers taking up space in the home and/or workplace; situations where they needed to charge their phone, but the available chargers were incompatible with it; and confusion about which charger works with what device. Around 15% to 20% of all survey respondents who experienced one or more of these problems reported it had caused them *significant* issues.

- Negative environmental effects: The production of each charger requires raw materials; their production and transport also generate CO_2 emissions. When chargers are no longer used, they generate electronic waste. The higher the number of chargers produced, used, and eventually discarded – and the more complex and heavier they are – the more significant these impacts. Mobile phone chargers are responsible for around 11,000 - 13,000 tonnes of e-waste per year, and associated life cycle emissions of around 600 - 900 kt CO_2e.

Policy options

The study explored a wide range of elements that could potentially be included within the scope of an initiative for a “common” or “harmonised” charger for mobile phones (and potentially other portable electronic devices). Following careful consideration of their relevance, proportionality, and technical feasibility, some of these elements were discarded from further analysis. Five policy options were retained for the in-depth assessment of their likely impacts (relative to the baseline). Three of these options concern the connectors at the device end, the other two the EPS. The key aspects of the options are summarised overleaf.

Option	Visualisation	Notes
0. Baseline (2018 MoU)		As per the MoU proposed by industry in 2018, cable assemblies can have either a USB Type-C or a proprietary connector at the device end. It is assumed that adaptors continue to be available for purchase.
1. USB Type-C only		Only cable assemblies with a USB Type-C connector at the device end are allowed. Cable assemblies that require adaptors are not considered compliant.
2. USB Type-C only; for phones with proprietary receptacles, adaptors in the box compulsory		Only cable assemblies with a USB Type-C connector at the device end are allowed. Manufacturers that wish to continue to use proprietary receptacles in their phones are obliged to provide an adaptor from USB Type-C to their proprietary receptacle in the box.
3. USB Type-C or proprietary; for cables with proprietary connectors, adaptors in the box compulsory		Cable assemblies can have either a USB Type-C or a proprietary connector at the device end. Manufacturers that choose to provide a cable with a proprietary connector are obliged to provide an adaptor in the box that enables its use with a USB Type-C receptacle.
4. Guaranteed interoperability of EPS		Commitment (via a voluntary agreement or an essential requirement enshrined in regulation) to ensuring all EPS for mobile phones are interoperable. This would need to be concretised via reference to compliance with relevant USB standards, in particular the interoperability guidelines for EPS (IEC 63002), which are currently being updated.
5. Interoperability plus minimum power requirements for EPS		To facilitate adequate charging performance, all EPS for mobile phones would have to guarantee the provision of at least 15W of power (in line with most current fast charging technologies). To also ensure full interoperability, all EPS would have to be capable of "flexible power delivery" in accordance with common (USB PD) standards / specifications.

Assessment and comparison of impacts

The summary table overleaf shows the impacts of the five policy options as such (applied to mobile phones only) relative to the baseline, and without taking into account any potential effects from increased voluntary decoupling that might follow from the options, or effects on other portable electronic devices (these are discussed separately below). As can be seen:

- **Social impacts**: Options 1, 4 and 5 would increase consumer convenience overall, mainly due to the enhanced ability to charge different phones with different chargers, the increased likelihood of finding a compatible charger while away from home (option 1), and/or reduced confusion about which charger works with what (options 4 and 5). There are also marginal benefits in terms of product safety and the illicit market from all options except option 3, due to the expected small reductions in demand for (potentially unsafe and/or counterfeit) stand-alone chargers.

- **Environmental impacts**: Relatively minor impacts occur due to (1) the small differences in weight between different charging solutions, and (2) reductions in stand-alone charger sales. The combination of these effects results in a very small positive net impact for option 4; a very small net negative impact for options 1, 2 and 3; and a slightly larger net negative impact for option 5. The impact of the options, particularly options 1, 2, 4 and 5, is quite sensitive to the assumptions on the impact they have on standalone sales, these assumptions are based on limited data and should be treated cautiously.

- **Economic impacts**: The price differences between different charging solutions, and the potential reductions in stand-alone charger sales, would result in net savings for consumers under options 1 and 4 (although under the latter these would be very small). Options 3 and 5, on the other hand, would impose additional costs on consumers (due to the cost of the adaptors or relatively higher cost of fast chargers), which are mirrored by an increase in revenue for the mobile phone industry. The other options would lead to a decrease in industry revenue, but this is likely to be on a scale that is (almost) negligible, expect for option 1 (which could also negatively affect the competitiveness of some firms in the supply chain). Some options would also entail adaptation costs for mobile manufacturers, but these are expected to be very minor except, again, in the case of option 1. Options 4 and 5 are expected to result in minor administrative / compliance costs (related to conformity assessment). Options 1, 4 and 5 would have a minor constraining impact on innovation.

Summary of the impacts of the policy options

Impacts		Connectors at the device end			EPS	
		Option 1	Option 2	Option 3	Option 4	Option 5
Social	Consumer convenience	+	0	0	+	+
	Product safety	0/+	0/+	0	0/+	0/+
	Illicit markets	0/+	0/+	0	0/+	0/+
Environ-mental	Material use	-/0	-/0	-/0	0/+	-/0
	E-waste & waste treatment	0	-/0	0	0	0
	CO_2 emissions	0	-/0	-/0	0/+	-
Economic	Operating costs for businesses*	-	-/0	0	0	-/0
	Administrative burdens for businesses*	0	0	0	-	-
	Competitive-ness of businesses*	-	0	+	-/0	+
	Costs for consumers	+	-/0	-	0/+	-
	Innovation and research	-	0	0	-	-

++ Major positive impact *+ Minor positive impact* *0 No or negligible impact* *- Minor negative impact* *-- Major negative impact*

** The options affect different kinds of businesses in different parts of the world in different ways; for details please see section 5.4.*

NB: All impacts are relative to the baseline scenario. Effects on voluntary decoupling or indirect effects on other portable electronic devices that may results from the options are not included in the scores.

It should be noted that any of the options for the device-end connectors (options 1, 2 or 3) could be combined with one of the options for the EPS (options 4 or 5). The net effects (both positive and negative) of such a combination of options would be expected to be the sum of the impacts of the options individually.

In addition to the main impacts included in the table above, the initiative could also have wider indirect impacts, mainly as a consequence of its potential contribution to increasing decoupling rates, and the potential impacts on portable electronic devices other than mobile phones. These issues were also considered as part of this study, but in less detail and with a more limited evidence base, meaning it was not possible to make specific (quantified) predictions and estimates. They are nonetheless important to keep in mind (see below).

Decoupling

This study has considered the extent to which the initiative as currently framed could help to facilitate voluntary decoupling, i.e. lead economic operators to offer phones without chargers, and their customers to make use of this option. To estimate the effects on voluntary decoupling that appear feasible, three decoupling scenarios (lower, mid and higher case) were defined. However, it is important to emphasise that the decoupling rates that are actually achieved would depend on a range of factors (including commercial decisions made by manufacturers and distributors, and possible accompanying measures, such as awareness raising campaigns, facilitated or supported by public authorities). While the policy options as defined for this study (see above) have the potential to contribute to this, their effects would be very indirect and uncertain, and are therefore not modelled as part of the impact assessment per se. Instead, the likely impacts of the decoupling scenarios were estimated separately.

As shown in the table below, the higher the decoupling rates, the greater the environmental benefits and the cost savings for consumers, as well as the convenience benefits for consumers who feel they have too many chargers taking up space in their home and/or workplace. However, the higher decoupling scenarios would also be likely to lead to a certain growth in the market for standalone chargers and, by extension, in the sales of unsafe and/or counterfeit chargers.

Summary of the impacts of the decoupling scenarios

Impacts		**Decoupling scenarios**		
		Low (max. 5% for EPS, 2.5% for cables)	**Mid** (max. 15% for EPS, 7.5% for cables)	**High** (max. 40% for EPS, 20% for cables)
Social	Consumer convenience	0	0/+	+
	Product safety	0	-/0	-
	Illicit markets	0	-/0	-
Environ-mental	Material use	+	+/++	++
	E-waste & waste treatment	+	+/++	++
	CO_2 emissions	+	+/++	++
Economic	Cost for consumers	+	+/++	++
	Margin for producers	-	-/--	--

++ Major positive impact   *+ Minor positive impact*   *0 No or negligible impact*   *- Minor negative impact*   *-- Major negative impact*

NB: All impacts are relative to the baseline scenario, which assumes no decoupling.

Other portable electronic devices

As regards other small portable electronic devices requiring similar charging capacity as mobile phones, the study considered two main questions:

Would a common charger for mobile phones have indirect effects on the markets for other portable devices?

The fact that such a high proportion of consumers own a mobile phone means that phones have an influence on the market for other devices. For example, it is already relatively common for some small devices (such as action cameras, e-readers, and wearables) to be sold without a complete charging solution (usually with a cable, but without an EPS); this is based partly on the expectation that customers will be able to use their mobile phone chargers. The adoption of a common connector and/or EPS across all mobile phones could therefore be expected to also contribute to a greater and/or faster adoption of this in other electronic devices in which this makes technological, practical and commercial sense (which would likely be the case for many but not all small devices; see below). It could thus reinforce the existing trend of a gradual increase in the take-up of USB Type-C und USB PD technology and standards in other markets, with the requisite convenience benefits for users of such devices. In turn, this could also have the indirect effect of increasing decoupling rates for certain devices.

Could / should the scope of a possible initiative be extended to include devices other than mobile phones?

From a technical perspective, both USB Type-C connectors (option 1) and compliant EPS (options 4 and 5) could be used for a wide range of devices, including tablets, e-readers, wearables, and even laptops (although the latter require significantly more power, and would therefore only charge very slowly with the kind of EPS envisaged here). Having a single common charger across different types of devices would be likely to increase consumer convenience overall.

However, making the use of such chargers (connectors and/or EPS) mandatory for devices beyond mobile phones would give rise to a number of issues and concerns, the most significant of which are: cost implications (requiring devices, especially low value ones, to ship with a charger that is more sophisticated and/or powerful than required would increase their cost for consumers); devices with specific requirements (e.g. very small devices, or those that operate in extreme environments, and for which USB Type-C connectors would not be appropriate); and, loosely related to this, the product scope (in the absence of a usable definition of what constitutes a “small portable electronic device”, the types of devices covered would need to be considered very carefully).

Specifically regarding options 4 and 5, these concerns could be partly mitigated by the following consideration: as outlined above, certain kinds of small devices are already routinely sold without an EPS. Thus, although a requirement for the EPS to meet certain requirements may appear unnecessarily stringent (and expensive) for certain devices, this could lead more manufacturers to choose to not include one. In this way, extending option 4 (or 5) to other portable electronic devices could have a positive effect on voluntary decoupling rates for such devices, and lead to fewer EPS being produced and discarded.

<u>**Concluding remarks**</u>

Based on our analysis of the likely social, environmental and economic impacts of the options defined for this study, there is no clear-cut “optimal” solution. Instead, all options involve **trade-offs**, and whether or not the marginal benefits (compared with the baseline) are deemed to justify the marginal costs is ultimately a political decision that also needs to take into account the residual risks and uncertainties identified by the study.

Options 1, 4 and 5 would address different facets of **consumer inconvenience** to varying degrees (but options 2 and 3, which were devised as possible compromise solutions, would not generate any significant net benefits in this respect, and are therefore unlikely to be worth pursuing further). A combination of option 1 with options 4 or 5 would result in the most significant consumer convenience gains. However, it should be noted that further convergence towards USB Type-C connectors as well as fast charging technologies that are compatible with USB PD is expected to occur anyway. This means that the marginal consumer convenience benefits would be minor rather than major, and result mainly from the *elimination* under option 1 of proprietary connectors (which, under the baseline scenario, are assumed to continue to account for a little over 20% of the market), and/or the *guarantee* that all EPS will be interoperable with all mobile phones (options 4 and 5), which in practice is already the case for the majority of EPS today (and appears likely to increase further under the baseline scenario).

As regards the negative **environmental impacts** generated by the current situation, all options have the *potential* to contribute to mitigating these to some extent by facilitating voluntary decoupling. However, the extent to which this would occur in practice is highly uncertain, and the ineffectiveness of the first (2009) MoU in this respect raises serious doubts that decoupling would follow automatically from the standardisation of chargers (especially connectors) alone. Therefore, the policy options assessed in this study *per se* are unlikely to generate significant environmental benefits (in fact, most are likely to result in very minor environmental costs). Achieving a reduction in material use, e-waste, and GHG emissions would require additional measures to facilitate and/or incentivise the sale of mobile phones without an EPS and/or cable assembly. A more in-depth analysis would be needed to determine if and how this could be achieved via non-regulatory or regulatory measures.

This study has also considered to what extent the various options would be likely to result in **unintended negative effects**. It concludes that none of the options are likely to lead to increased risks from unsafe and/or counterfeit chargers (although both would be a concern in the event of significantly higher decoupling rates). However, there are economic costs for certain economic operators (most of whom are not based in the EU), some of which are likely to be non-negligible. We also conclude that options 1, 4 and 5 would have a negative effect on innovation, because they would rule out the rapid adoption of any new "game-changing" charging technology in wired mobile phone chargers, thereby reducing the incentives for firms to invest in research and development to seek to gain a competitive advantage, which in turn also risks reducing the pace of "incremental" innovation as regards future generations of "common" (USB) technologies. Nonetheless, the implications of these constraints seem more significant in theory than in practice, in view of the way the market is evolving at present, and companies' own interest in ensuring interoperability.

In summary, the most effective approach to addressing the consumer inconvenience that results from the continued existence of different (albeit mostly interoperable) charging solutions would be to pursue **option 1 (common connectors) in combination with option 4 (interoperable EPS)**. If accompanied by other measures to stimulate decoupling, this could also contribute to achieving the environmental objectives. Introducing such a "common" charger for mobile phones would be likely to also foster its adoption among certain other portable electronic devices, thus generating additional *indirect* consumer (and potentially environmental) benefits. However, whether or not other devices should be encompassed within the scope of the initiative (i.e. the requirement to use the "common" charger be applied to other devices too) needs to be considered carefully. While it appears likely that the benefits would outweigh the costs for certain devices that are broadly similar to mobile phones (in particular tablets), the same is not necessarily the case for other categories of devices that have significantly different uses, functionalities and price ranges (such as many wearables).

In any case, when determining whether or not to pursue this initiative, the question of whether the expected negative economic impacts appear justified by the scale and scope of the social and environmental benefits needs to be given due consideration. The balance would depend partly on the policy instrument used: if the industry was able to make a **voluntary commitment** to implement options 1 and/or 4 (and work with public authorities to explore ways of increasing decoupling rates), this could secure most of the available benefits, while providing enough flexibility to alleviate most of the concerns around unintended negative economic impacts. Should it not be possible to reach a voluntary agreement (as has been the case in the past), **regulation** could provide an alternative solution. However, as noted above, there are important trade-offs and risks to consider, as well as question marks about the legal basis for a regulatory proposal (depending on its exact scope).

1. INTRODUCTION

This report contains the final results of the Impact Assessment Study on the Common Chargers of Portable Devices. The **aim of this study** is to provide input for the Commission impact assessment accompanying a new initiative to limit fragmentation of charging solutions for mobile phones and similar devices, while not hampering future technological evolution.

The report was written by Ipsos, Trinomics and Fraunhofer FOKUS (on behalf of a consortium led by Economisti Associati), based on research and analysis undertaken between January and November 2019. It was commissioned by the European Commission (Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs).

The report is structured as follows:

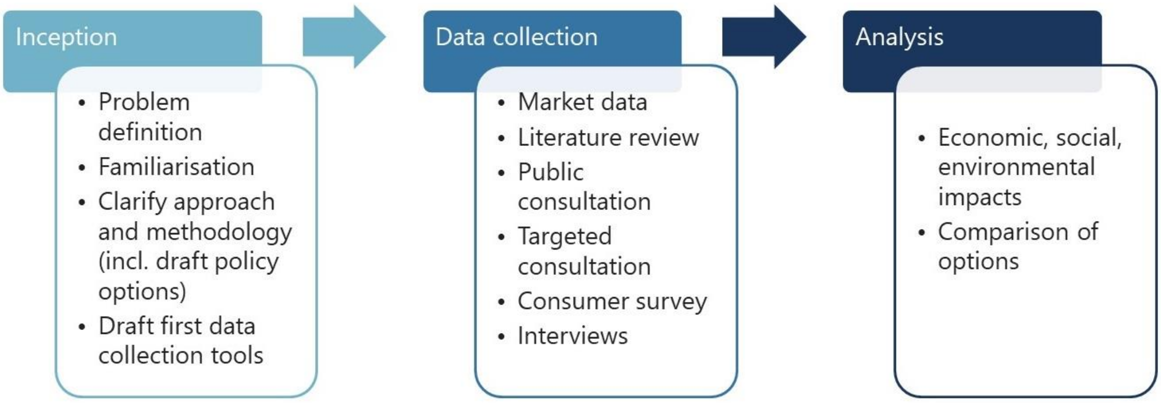
- **Chapter 2** provides a brief overview of the methodological approach to the study.
- **Chapter 3** contains a detailed discussion of the current situation regarding chargers for mobile phones, including the identification of the main problems the initiative is intended to address.
- **Chapter 4** describes the baseline and the concrete policy options that have been shortlisted for in-depth assessment, following a discussion of a wider range of elements that were considered.
- **Chapter 5** contains the analysis of the likely social, environmental and economic impacts of the different options, as well as important considerations regarding the expected decoupling rates and other potential implementation issues, including possible indirect and direct impacts on portable electronic devices other than mobile phones.
- **Chapter 6** summarises the main likely impacts of all shortlisted policy options, and compares these to provide an aid to the political decision making process this study is intended to support.
- The **Annexes** contain supporting materials, including details on the methodological approach, synopsis reports with the main results of the Commission's public consultation and the consumer panel survey carried out by Ipsos, as well as product fiches with additional market and technological data.

2. METHODOLOGY

Our overall approach employed a mixed method, combining two main tasks. First, defining the problem (including a market and technology analysis as well as an assessment of the effectiveness of the previous MoU), and second, an assessment of the likely impacts of a set of policy options going forward.

The main tasks of the methodology were structured across three phases. The inception phase included an initial definition of the problems that exist in the current situation, and of possible policy options to address these, as discussed in detail in chapter 4. Policy options were reviewed and finalised during our data collection phase, and a comprehensive impact analysis and comparison of policy options at hand was produced during the analysis phase.

Figure 1: Overall study approach



<u>Sources of evidence</u>

The evidence base for this study includes both primary and secondary data. As part of this study, we consulted and collected information from a variety of stakeholders (including consumers and industry representatives). More specifically, this included:

- An online panel survey of a sample of around 5,000 consumers across ten EU Member States

- 37 in-depth interviews with representatives of all key stakeholder groups (relevant industry sectors, civil society, and public authorities); see the table below for further details.[1]

- Where relevant, the study also drew on the results of the public consultation designed and launched by the European Commission, addressed to interested parties at large, including potentially all stakeholders as well as EU citizens. The consultation drew 2,850 responses, the vast majority of which (96%) from EU citizens.

[1] Members of the study team contacted a total of 79 relevant stakeholders for interviews. Over half of these declined or did not respond to the request in spite of at least one follow-up message. Nonetheless, the interview programme covered a good cross-section of representatives of all main stakeholder groups that were targeted.

Table 1: Overview of stakeholder interviews conducted

Main groups	Sub-groups	Number of interviews
Industry	Mobile phone manufacturers[2]	7
	Charger manufacturers	2
	Manufacturers of other portable electronic devices	2
	Semiconductor chip manufacturers	2
	Distributors (companies and associations)	4
	Associations and fora representing the digital tech industry and/or related sectors	6
Civil society	Consumer organisations	4
	Environmental NGOs / experts	2
	Product safety organisations	1
Public authorities	European / international organisations and standardisation bodies	4
	National authorities of EU Member States	3

In addition to the fieldwork carried out, a comprehensive desk review of existing literature and market data was undertaken. This allowed us to collect information on a number of important aspects, including: the market for mobile phones and chargers; key features of mobile phone chargers, and relevant industry standards; information on other devices that might be charged with mobile phone chargers; and data on relevant economic, environmental, product safety and other considerations.

Based on the evidence collected, a stock model of mobile phone chargers was developed to assess the impacts of each policy option on the composition of the mobile phone chargers stock across the EU. This model compiled charger (phone) sales data and matched this with data and assumptions on charger disposals to simulate changes in the stock of chargers in use in the EU28. The model enabled calculation of quantitative estimates of environmental impacts and impacts on costs. For details on the model and the main underlying assumptions, see Annex E.

Assessment of key impacts

The study used a range of data sources and analytical techniques to estimate (where possible, quantitatively) the most significant likely impacts of the policy options under consideration. In particular:

- **Impacts on consumers**: Potential consumer impacts of different policy options developed relate to the level of inconvenience experienced by consumers when using mobile phone chargers, the frequency with which certain problems were encountered, and any costs incurred as a result. Evidence on these elements was collected through a panel survey of a sizeable, representative sample of EU consumers. A research panel is a group of

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[2] In addition to interviews, mobile phone manufacturers were also sent a follow-up questionnaire requesting additional specific data and information. In total, 6 interviews were carried out and 5 questionnaire responses received, from a total of 7 different companies (4 of which contributed in both ways).

previously recruited respondents who have agreed to take part in surveys and/or other research. The survey covered 10 Member States (incl. five of the largest ones – Germany, France, Italy, Poland, and Spain; as well as the Czech Republic, Hungary, the Netherlands, Romania and Sweden), and collected 500 responses per country. Survey data was weighted to produce a representative and comprehensive picture of consumer opinion and experience across the EU. Apart from questions on the type of chargers used and the nature of use, the survey also included a conjoint experiment which provided insights into the relative importance of product attributes related to interoperability and charging performance.

- **Environmental impacts**: As part of the prospective impact assessment, changes in environmental impacts across the different policy options were identified using evidence from desk review of relevant documents, such as Life Cycle Impact Assessment studies, the consumer survey, stakeholder consultations and market data. Unit level impacts of the key charger components (external power supply, cable and adaptor) were estimated and then multiplied by the number and type of chargers produced and discarded per year in the EU as calculated using the stock model to estimate total impacts. The impacts considered include GHG emissions, material use and e-waste generation. The main environmental impacts of the future initiative relate to two key factors: (1) the change in composition of charger types under different policy options; (2) the decoupling of new chargers from device sales. In other words, significant benefits would materialise if chargers were interchangeable and the number of unnecessary chargers sold were to decline, which is unlikely to occur while mobile phones and other devices are routinely sold with a charger or if competing mutually incompatible devices proliferate.

- **Economic impacts**: The main potential economic impacts of the initiative relate to the additional costs of (or savings from) the new requirements for both consumers and economic operators, as well as impacts on innovation and technological development. To the extent possible, costs were estimated via the stock model, while the analysis of other impacts on economic operators relied heavily on information collected from industry representatives (incl. manufacturers of mobile phones, manufacturers of other portable electronic devices, manufacturers of chargers, and distributors). In addition to 22 in-depth interviews with industry representatives, evidence made available by industry to the study team was analysed on top of responses submitted to the public consultation and secondary data.

Based on the policy options and impact screening finalised at the interim stage of the study, the options were compared using Multi-Criteria Analysis (cost-benefit analysis was not feasible due to the fact that some key impacts could not be quantified or monetised). This combined the results from the impact analysis to enable an objective comparison of the relative costs, benefits and impacts of the options. More detail on our options assessment is provided in section 6.

Main limitations and caveats

Limitations to our approach stem from the assumptions made in the stock model, e.g. on production costs, charger weight and composition and future development of the mobile phone market. Whilst we have used the best available evidence, part of the assumptions underlying the stock model and our options assessment relied on inputs from a small number of key stakeholders, or a small number of secondary sources. We are confident that the stakeholders consulted represent a significant proportion of relevant markets (in particular the mobile phone market, where the interviewed companies account for a cumulative share of over 75% of the EU market), and all analytical outputs were cross-checked and subjected to internal reviews. However, a certain level of uncertainty remains around the assumptions made in our stock model.

Furthermore, whilst is the study was able to gain access to comprehensive market data available on mobile phone sales and shipments, we found a lack of comprehensive market statistics on standalone chargers and the illicit market. Therefore, data on standalone chargers and illicit markets are mainly drawn from the consumer panel survey and stakeholder consultations, leaving some residual uncertainty. Similarly, due to the primary focus of the study on mobile phone chargers, it was not in a position to analyse the markets for other portable electronic devices, and of the potential impacts of the initiative on them, in the same level of depth. Therefore, the analysis for such devices is less detailed, and subject to a higher level of uncertainty.

Finally, there might be disruptive technological change which could render the focus on mobile phone chargers irrelevant, and instead raise questions on harmonisation of novel products in consumer electronics. This study did not attempt to undertake a comprehensive horizon scanning exercise to factor in potential future developments of new technology in this field.

3. THE CURRENT SITUATION

The European Commission is considering a new initiative to limit fragmentation of the charging solutions for mobile phones (and potentially other portable electronic devices). This chapter summarises the policy, technological and market context of this initiative, and provides an assessment of the main implications and issues it causes, as well as other important considerations, such as the views of key stakeholders about possible unintended effects. The chapter ends with a summary of the nature and scale of the main problems the initiative is intended to address.

3.1 Policy context

In June 2009, following a request from the European Commission, major producers of mobile telephones agreed to sign a **Memorandum of Understanding** ("MoU") to harmonise chargers for data-enabled mobile telephones sold in the EU.[3] The signatories[4] agreed to develop a common specification based on the USB 2.0 micro-B interface, which would allow full charging compatibility with mobile phones to be placed on the market. For those phones that did not have a USB micro-B interface, an adaptor was allowed under the terms of the MoU. The MoU expired after two letters of renewal in 2014.

A **study carried out by RPA** in 2014[5] found that the MoU signed in 2009 was effective at harmonising charging solutions and improving consumer convenience. Compliance rates were very high (99% of smartphones sold in 2013 were compliant with the MoU), although it should be noted that one major manufacturer continued to use proprietary charging solutions (Apple switched from its 30-pin connector to the Lightning connector in 2012), which were compliant by virtue of Apple having made an adaptor available for purchase. The study also recognised that decoupling had not been achieved to any significant extent, with only a handful of companies in Europe offering the possibility to consumers to buy a phone without the charger, hence limiting the expected benefits for the environment.

Ever since the MoU expired, the European Commission has been trying to foster the adoption of a **new voluntary agreement**. The European Parliament and the Council also called in 2014 for renewed efforts to complete the harmonisation of chargers.[6] Relevant provisions were included in the Radio Equipment Directive (RED)[7] adopted in 2014: Article 3(3)(a) defines as one of the "essential requirements" for all radio equipment (including mobile phones) placed on the market that it "interworks with accessories, in particular with common chargers". Recital 12 further specifies that interoperability between radio equipment and accessories such as chargers "simplifies the use of radio equipment and reduces unnecessary waste and costs"' it goes on to argue that a "renewed effort to develop a common charger for particular categories or

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[3] For more information on the Commission's campaign, as well as the text of the 2009 MoU, see: https://ec.europa.eu/growth/sectors/electrical-engineering/red-directive/common-charger_en

[4] The MoU was originally signed by 10 companies, and four other companies signed it later. Original signatories: Motorola, LGE, Samsung, RIM, Nokia, Sony Ericsson, NEC, Apple, Qualcomm and Texas Instruments. Subsequent signatories: Emblaze Mobile, Huawei Technologies, TCT Mobile and Atmel.

[5] RPA (2014): Study on the Impact of the MoU on Harmonisation of Chargers for Mobile Telephones and to Assess Possible Future Options

[6] URL: http://www.europarl.europa.eu/news/en/press-room/20140307IPR38122/meps-push-for-common-charger-for-all-mobile-phones

[7] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment

classes of radio equipment is necessary", and in particular, that "mobile phones that are made available on the market should be compatible with a common charger."

Following several rounds of internal discussions within Digital Europe (the European organisation that represents the digital technology industry) and exchanges of views with the Commission, the **industry proposed a new MoU** on the future common charging solution for smartphones in March 2018.[8] The seven signatories[9] agreed to "gradually transition to the new common charging solution for Smartphones based on USB Type-C", while noting that it has the ability to also be the "common charging interface for other types of portable electronic equipment". The MoU covers wired charging solutions, and considers the following cable assemblies to be compliant:

- a cable assembly that is terminated on both ends with a USB Type-C plug;
- a cable assembly that is terminated on one end with a USB Type-C plug and has a vendor-specific connect means (hardwired/captive or custom detachable) on the opposite end; and
- a cable assembly that sources power to a USB Type-C connector from a USB Type-A connector.

However, the **Commission has refused to endorse the new MoU**, stating that it does not fully align with the EU's harmonisation objectives, which seek to limit fragmentation of the charging solutions for mobile phones and similar devices. The new MoU continues to allow for proprietary solutions ("vendor-specific connect means"), which the Commission no longer considers justified in view of the technical advantages provided by the introduction of the USB Type C. Therefore, according to the Commission, the new MoU would neither address the remaining fragmentation of the chargers, nor exclude the possibility of other new proprietary solutions emerging in the future.

In a letter[10] sent to Commissioner Elżbieta Bieńkowska in October 2018, a number of **MEPs also expressed their disappointment** with the Memorandum of Understanding, which in their view "neither has a scope that extends beyond smartphones, nor solves the fragmentation in that sector, showing the limitations of voluntary approaches, where vetoes of strong market players influence the outcome and lead to an unsatisfactory approach also in terms of environmental policy objectives." They therefore urged the Commissioner to "take a decisive action in the direction of adopting a delegated act on this matter", making use of the power conferred to it under Article 44 of the RED.

The European Commission argues that **further harmonisation** would lead to increased consumer convenience, as they would be able to charge not only mobile phones but potentially also other portable devices with a common cable (and charger), as well as being offered the option of retaining existing chargers and purchasing mobile phones without chargers for a lower price. A harmonised solution, according to the Commission's initial analysis,[11] is also expected to reduce the number of counterfeit chargers in the market, reduce the import needs of chargers (as consumers could keep using their old chargers), and reduce electronic waste. At the

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[8] Memorandum of Understanding on the future common charging solution for smartphones, 20 March 2018, available at URL: https://www.digitaleurope.org/resources/memorandum-of-understanding-on-the-future-common-charging-solution-for-smartphones/

[9] Apple, Google, Lenovo, LG Electronics, Motorola Mobility, Samsung, and Sony Mobile

[10] Letter to Commissioner Elżbieta Bieńkowska RE: Common charger for mobile radio equipment. Brussels, 5 October 2018. Ref. Ares(2018)5123708

[11] European Commission Inception Impact Assessment. Ref. Ares (2018)6473169 - 15/12/2018

same time, the Commission recognises that any further harmonisation should not limit innovation, i.e. the development and diffusion of new generations of chargers.

3.2 Key technological developments

Since 2009, a number of important technological developments have taken place that have improved the performance of charging solutions and introduced new technologies to consumers. This section provides an overview of the main features that influence interoperability, including the main components of chargers, and the status of fast and wireless charging.

A charging solution is formed by three main elements: the external power supply (EPS), a cable assembly connecting the EPS to the device, and the battery included in the device. For a device to charge, these three elements need to be interoperable. Charging solutions are normally designed ad-hoc to meet the devices' requirements, defined as "charging profile". The charging profile describes the variation of the current and the voltage during the charge, and depends on the type of battery and the recharge time. Interoperability, in summary, relies on the following:

EPS providing the current and voltage that the battery needs, determined by the battery's charging profile;

A cable connecting the EPS to the device supporting the power being transmitted, with plugs (connectors) at both ends that are compatible with the EPS and the device.

The External Power Supply (EPS)

Following the MoU signed in 2009, CENELEC received a mandate from the European Commission to develop a harmonised standard for mobile phone chargers. In response, CENELEC created a task force to develop the interoperability specifications of a common EPS, and work was transferred into the International Electrotechnical Commission (IEC). The IEC published the standard IEC 62684 in 2011, and updated it in 2018. This standard specifies the interoperability of common EPS for use with data-enabled mobile telephones. It defines the common charging capability and specifies interface requirements for the EPS.[12]

According to the interviewees consulted for this study, this standard was widely adopted by the industry. As technology evolved and smartphones required higher power than 7.5W (the maximum power allowed by the IEC 62684 is 5V at 1.5A), new technologies emerged to cover this need. For example, in 2013 Qualcomm released Quick Charge 2.0[13], which provided maximum power of 18W by increasing the current and the voltage of the common charger. Since then, Qualcomm has released Quick Charge v3, v4 and v4+. Quick Charge comes with Snapdragon devices and it has been adopted by a large number of mobile phone manufacturers, such as Samsung, Motorola, OnePlus, Oppo, LG, Xiaomi, and Sony.

In parallel, the USB Promoter Group, formed by 100 members of UBS-IF[14], was working to develop new battery charging specifications. In 2013 it set a cooperation

[12] IEC 62684:2018 defines interoperability based on legacy USB technologies and does not cover charging interfaces that implement IEC 62680-1-3, IEC 62680-1-2 and IEC 63002

[13] Presentation prepared by Qualcomm for a meeting with the European Commission, DG GROW, on 8 September 2016

[14] The USB-IF is a non-profit industry group. It defines itself as "the support organization and forum for the advancement and adoption of USB technology as defined in the USB specifications".

agreement with IEC to support global recognition and adoption of USB technologies in international and regional standards and regulatory policies. As a result of the work carried out by the USB Promoter Group and USB-IF, IEC published in 2016 the standard series IEC 62680. This standard series set the specifications for USB Power Delivery (IEC 62680-1-2) and USB Type-C (IEC 62680-1-3). Both standards were last revised in 2018.

The USB Power Delivery (PD) specification describes the architecture and protocols to connect the battery charger and the device to be charged (e.g. a smartphone). During this communication, the optimum charging voltage and current are determined to deliver power up to 100W through the USB connector. Some mobile phone manufacturers have since incorporated USB PD in their devices, such as Apple, Google, and Huawei. Samsung has recently announced new charging solutions based on USB PD.

The USB Type-C specification is intended as a supplement to the existing USB 2.0, USB 3.1 and USB PD specifications. It defines the USB Type-C receptacles, plugs and cable assemblies. This specification also sets charging requirements up to 15W, and specifies the use of USB PD if the charge exceeds 15W.

On 8 January 2018, USB-IF announced the "Certified USB Fast Charger" which certifies chargers that use the feature "Programmable Power Supply" (PPS) of the USB PD specification. Qualcomm's Quick Charge v4 and v4+ incorporate PPS and therefore is compatible with USB PD.

Interoperability of the "USB PD family" is defined by the standard IEC 63002, released in 2016. This standard provides guidelines for the device and EPS to "communicate with each other", so that the EPS provides only the power that the device requires, avoiding damaging the battery and maximising performance.

In summary, EPS today can be classified into four main typologies, as described in the table below.

Table 2: Typology of external power supply (EPS) for mobile phones

Type of EPS	Specifications applicable	Interoperability with low-end and old phones	Interoperability with high end phones
Common EPS, as defined in 2009 MoU	IEC 62684	Yes	Can charge high-end phones at a normal speed
USB PD	IEC 62680-1-2 IEC 62680-1-3 IEC 63002	Yes	Yes
Quick Charge v1, v2, v3	None	Yes, although safety (for user and device) is not guaranteed	Only phones including Quick Charge
Quick Charge v4, v4+	Programmable Power Supply Compatible with USB PD and USB C specifications	Yes	Yes

When consulted for this study, phone manufacturers were asked about compliance of their products (mobile phones and chargers included in the box) with these standards. All manufacturers confirmed that their chargers and mobile phones with charging capacity of up to 5W comply with 62684. Only two companies provided information on devices using more than 5W. In one case, all devices are compliant with IEC 62680 series and IEC 63002, whereas in another case there is a mix of devices compliant with 62680 series and 63002, and devices with proprietary fast charging solutions.

The study team conducted a review of phones available in the market, and triangulated this data with data provided by IDC (a leading global provider of market intelligence) on shipments of mobile phones per model, in units, in 2018. Based on this, we estimate that in 2018, 71% of phones sold in the EU included an EPS in the box that is compatible with IEC 62684, 11% included an EPS compliant with USB PD specifications, and 18% included an EPS using a proprietary solution. Among the latter, it should be noted that some proprietary solutions (Quick Charge v4 and v4+) are compatible with USB PD and USB Type-C specifications, and therefore interoperable with other devices. We assume that a large proportion of these devices incorporated the latest Quick Charge solutions (v4 and v4+).

The cable assembly

The cable assembly is another element that determines interoperability. When the first MoU was signed in 2009, signatories committed to use **USB micro-B connectors at the phone end**. The MoU, however, also allowed the use of proprietary connectors. The shape of the connector at the **EPS end** was not directly covered by the 2009 MoU. However, the standard that defined "the common charger" (IEC 62684) indicated that EPS need to be "provided with a detachable cable and equipped with a **USB Standard A** receptacle to connect to the EPS".

To date, the majority, if not all, of mobile phone manufacturers complied with the requirement of providing an EPS with a detachable cable and USB A sockets and plugs. Similarly, most mobile phone manufacturers adopted USB micro-B at the phone end, and this has been the mainstream solution until the irruption of USB Type-C. USB Type-C is a 24-pin USB connector system, which is distinguished by its two-fold rotationally-symmetrical connector. The specification was finalised and announced by the USB-IF in 2014, and IEC published the standard in 2016. The IEC 62680-1-3 sets specifications for connectors, cables, adapters, supporting charge of up to 15W. However, it can also support USB PD (up to 100W). Since then, USB C has started to gradually replace USB micro-B as the connector of choice at the device end (starting in higher-end phones).

The exception is Apple's proprietary connector, Lightning, which has been incorporated in all iPhones, iPads and iPods since 2012, and continues to be used in the last generation of iPhones launched in 2019. However, some other devices launched recently by Apple, however, include USB Type-C (e.g. IPad Pro 11-inch, iPad Pro 12.9-inch and Mac: 12 inch MacBook, MacBook Air, and MacBook Pro-Thunderbolt 3, to mention a few). According to Apple itself, an important difference between Lightning and USB Type-C is that the former is not capable of providing as much power (100W) as the latter, which means Lightning connectors and cables require slightly less material (and are therefore lighter), and also – more importantly – that the corresponding receptacle occupies less space inside the phone.

Table 3. Maximum power and speed for data transfer supported by USB connectors

Type of connector	Latest specification it supports (power)	Latest specification it supports (data transfer)	Max Power	Max data transfer
USB micro-B	IEC 62684	USB 2.0	7.5 W	480 Mbps

Type of connector	Latest specification it supports (power)	Latest specification it supports (data transfer)	Max Power	Max data transfer
USB Type-A	USB PD (IEC 62680-1-2)	USB 3.2	100W	20 Gbps*
USC Type-C	USB PD (IEC 62680-1-2)	USB 4	100W	40 Gbps

**Maximum data transfer of USB A may be increased up to 40 Gbps with Thunderbolt (Intel's proprietary solution)*

<u>Wireless charging</u>

Wireless charging is an incipient technology (meaning that it is currently situated at the beginning of the life cycle) to charge portable devices. At the moment, its energy efficiency is around 60%, whereas energy efficiency for wired technologies is close to 100%.[15] There are three main technologies for wireless charging: Airfuel, Qi and PMA:

- Power Matters Alliance (PMA) was a global, not-for-profit, industry organisation whose mission was to advance a suite of standards and protocols for wireless power transfer.
- PMA was merged with Alliance for Wireless Power (A4WP) in 2015 to form AirFuel Allliance, an open standards organisation formed by companies in the field of consumer electronics and mobile technology. It has developed two wireless charging technologies: AirFuel Resonant and Airfuel RF.
- Qi was developed by the Wireless Power Consortium, formed by Apple, Google, LG Electronics, Philips, Qualcomm and Samsung, amongst others.[16]

Qi and PMA seem to have been the preferred technologies by mobile manufacturers to date. Most smartphones (Apple and Android devices) use the Qi technology, although some devices, including Samsung's, are also compatible with PMA. Qi was released in 2008, and by February 2019 there were over 160 devices which had Qi built-in.[17] Wireless chargers only work with compatible devices. The iPhone X, iPhone 8, and many Android phones, including Huawei, allow wireless charging. Figure 5 in Section 3.3 includes information on the evolution of wireless enabled mobile phones, which were estimated to be 44% of total mobile phones sold in the EU in 2018.

IEC TC 100, the IEC Technical Committee for "Audio, video and multimedia systems and equipment", has standardised and published two documents on wireless charging protocols: IEC 63028 (AirFuel Wireless Power Transfer System Baseline System Specification) and IEC PAS 63095 (The Qi wireless power transfer system power class 0 specification). According to the information provided by interviewees, there are other standards being developed by IEC TC 100 for energy efficiency related to wireless charging. It is foreseen that new technologies will be reviewed/standardised by IEC TC 100 when they become more mature.

[15] According to interviews conducted with technical experts.

[16] See full list of members here: https://www.wirelesspowerconsortium.com/about/board

[17] Source: https://qi-wireless-charging.net/qi-enabled-phones/ (accessed on 28 June 2019)

3.3 The market for mobile phone chargers

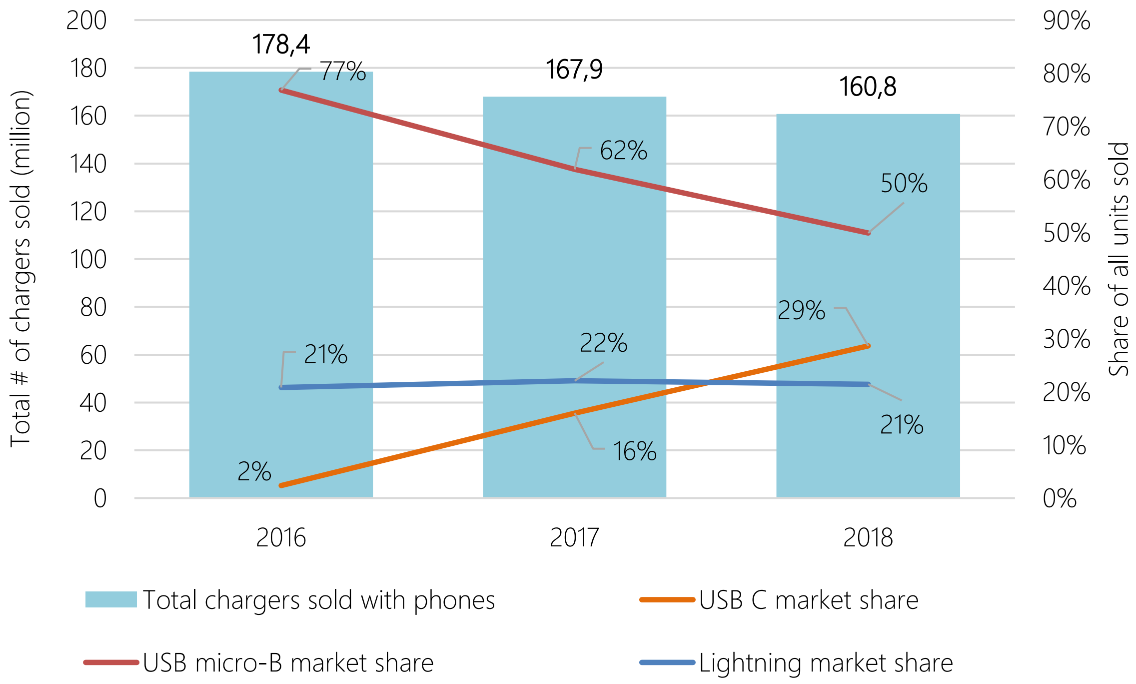
This section provides an overview of the current market for mobile phone chargers, including recent sales trends for key charging technologies sold "in the box" with mobile phones, as well as estimates of chargers sold separately. Based on this, we introduce the stock model we have developed to provide an indication of the mobile phone chargers that are currently in circulation and/or in use.

Market trends for mobile phone chargers sold "in the box" (2016-2018)

Overall shipments of mobile phone chargers sold together with mobile phones can be inferred from sales data on mobile phones across the EU. Across 2016-2018, overall unit sales of mobile phones fell by 10% (from 178 million to 161 million units), despite a 5% increase in the value of sales. The largest markets for mobile phones (and hence, chargers sold together with mobile phones) in the EU were the United Kingdom, Germany, France, Italy and Spain.

The market share of different charging technologies sold can be approximated by disaggregating overall phone sales by phone model and their respective charging solution. **Figure 2** below shows how the market shares for charging technologies – i.e. the **connectors at the device end** – has changed from 2016-2018.

Figure 2: Mobile phone chargers sold with mobile phones (2016-18, EU28)

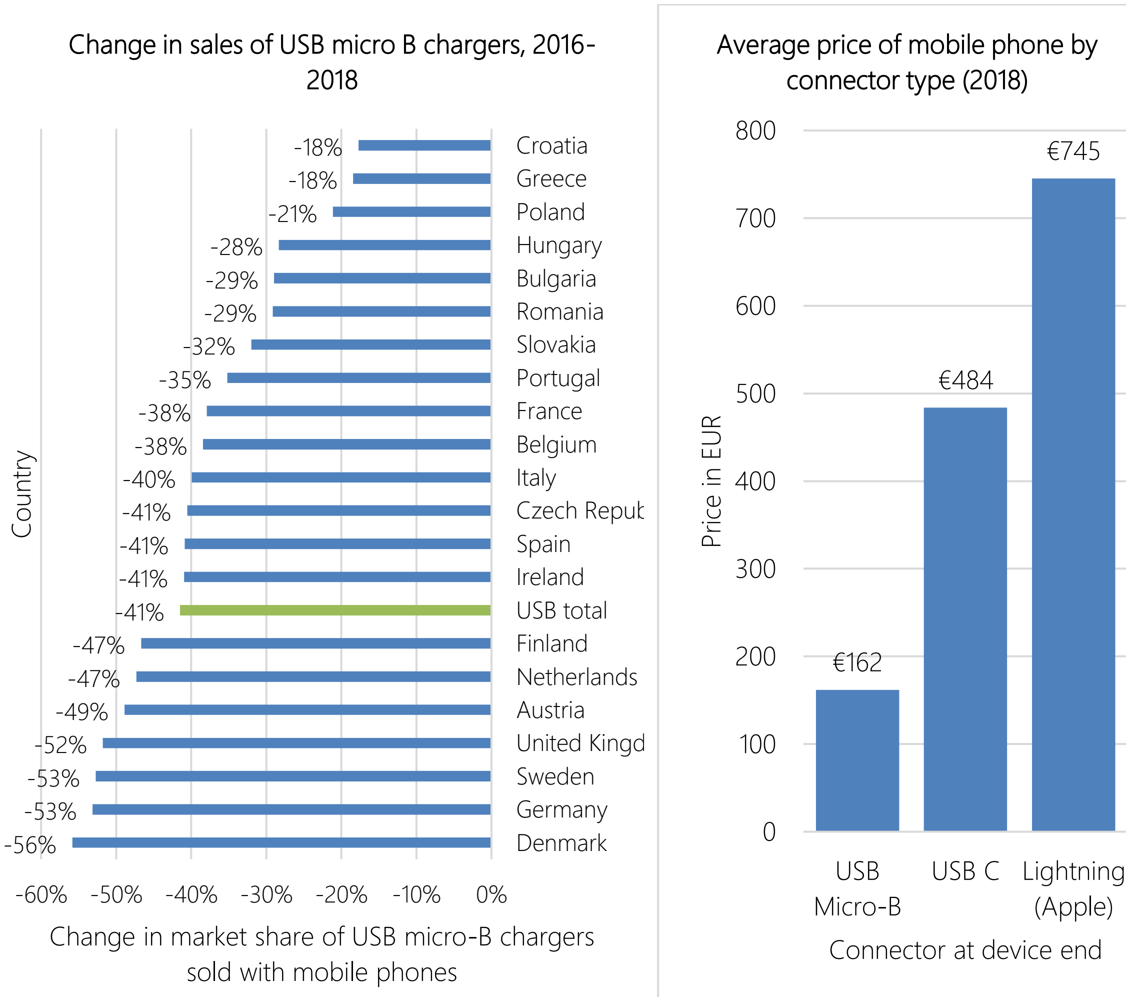


Source: IDC Quarterly Mobile Phone Tracker, Q1 2019
Note: Data excludes standalone chargers. IDC data covers 24 EU Member States (UK, Germany, France, Italy, Spain, Poland, Netherlands, Romania, Sweden, Portugal Hungary, Belgium, Austria, Czech Republic, Denmark, Greece, Finland, Ireland, Bulgaria, Slovakia, Croatia, Luxembourg, Malta and Cyprus). Data for the remainder (Estonia, Latvia, Lithuania, Slovenia) imputed based on Eurostat population statistics (Eurostat 2018).

The market share of chargers using Lightning connectors has stayed relatively consistent over the period from 2016 to 2018 (slightly above 20%). The market segments covering non-Lightning technologies have seen a clear trend towards uptake of USB Type C connectors, and are suggesting relatively rapid convergence towards this solution overall. The market share held by mobile phone chargers with a USB Type C connector grew from 2% to 29% between 2016 and 2018. The market share held by USB micro-B phones has fallen from 77% to 50%, as devices with USB Type C charging solutions gradually entered the market.

As USB Type C connectors are currently used primarily in higher-end (and therefore more expensive) phones, it is noticeable that the replacement rate in countries with lower average earning has been much slower. In 2018, sales of chargers with USB micro-B connectors still held the highest market share in Greece (76%), Portugal, Poland and Romania (68% respectively) and the lowest market share in Denmark (24%) and Sweden (25%).

Figure 3: Sales trends and average prices by connector types



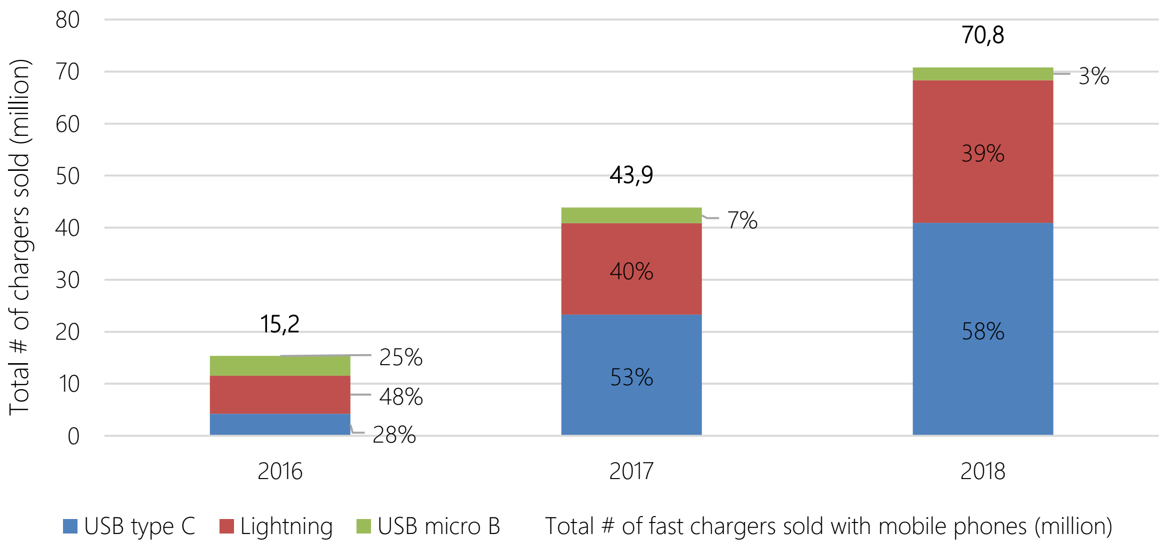
Source: IDC Quarterly Mobile Phone Tracker, Q1 2019
Note: Data excludes standalone chargers. IDC data does not include separate counts for Malta, Luxembourg or Cyprus. Shipments for these countries are included under Italy, Belgium and Greece respectively.

All data presented above relates to the connectors at the device (mobile phone) end. As regards the **connectors at the external power supply (EPS) end**, it is worth noting that, in 2018, practically the totality of chargers sold with phones used detachable cables with USB Type-A connectors. However, the first chargers with USB Type-C connectors at the EPS end started to appear on the European market in late

2017 (launched by Google), although they still accounted for less than 0.1% all mobile phone shipments in 2018 (according to IDC data). This proportion is expected to start to begin to grow from 2019, as other major manufacturers (including Samsung and Apple) have included chargers with USB Type-C EPS connectivity in some of the models they have launched in 2019.

Sales of **fast charging** solutions sold together with mobile phones have risen almost five-fold since 2016, to 71 million units in 2018, representing 44% of all sales in 2018. Sales of fast charging solutions sold with a USB type C connector grew faster than those with Lightning connectors, in line with overall market trends discussed above.

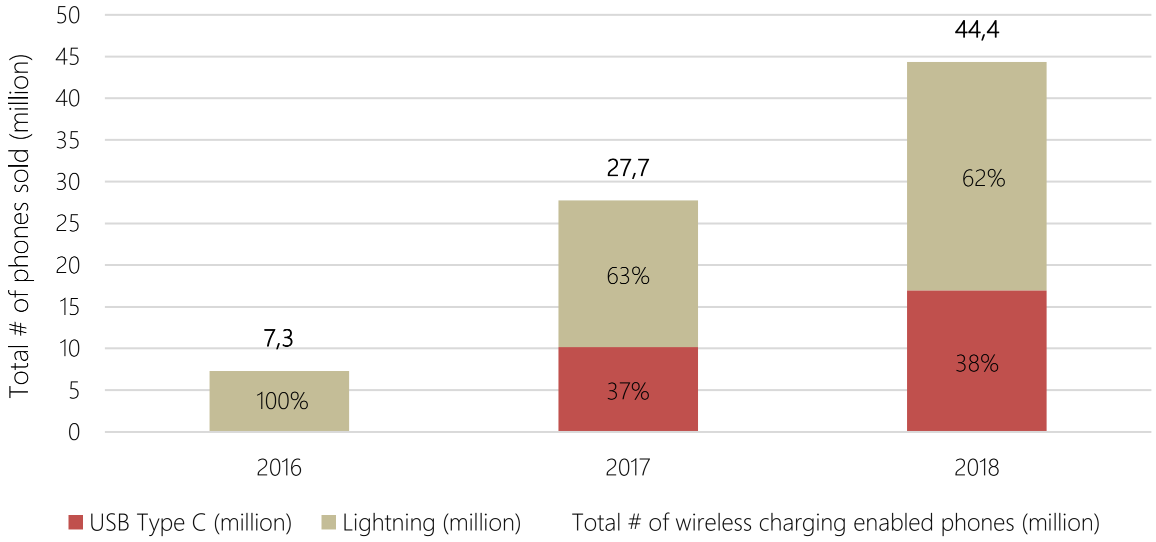
Figure 4: Fast charging solutions sold with a mobile phone (EU-28, 2016-18)



Source: Ipsos estimates using IDC Quarterly Mobile Phone Tracker, Q1 2019
Note: Data excludes standalone chargers. Data for Estonia, Latvia, Lithuania, Slovenia imputed based on Eurostat population statistics (Eurostat 2018).

Another major technology change being introduced into the market is **wireless charging**. Since wireless charging enabled phones were first introduced, they have seen widespread adoption. Between 2016 and 2018, their overall sales increased six-fold, rising to around 44 million, or around 28% of overall sales in 2018 (note that these numbers refer to wireless *enabled* phones, i.e. not to phones that come with a wireless charger, but those that *can be* charged with a wireless charger that needs to be purchased separately). The largest share of wireless enabled phones sold throughout 2016-2018 were Apple phones. This can be expected to change in 2019 though, with a number of new high tier mobile phones by various manufacturers now offering wireless charging functionality.

Figure 5: Shipments of wireless charging enabled phones (EU-28, 2016-18)



Source: Ipsos estimates using IDC Quarterly Mobile Phone Tracker, Q1 2019
Note: The estimates are based on a review of the main mobile phones models of the top 10 manufacturers in the years in question.
They exclude phones which require additional accessories other than wireless chargers to be purchased separately to 'activate' the wireless charging function. Data for Estonia, Latvia, Lithuania, Slovenia imputed based on Eurostat population statistics (Eurostat 2018).

Chargers sold separately

Although almost every phone is supplied with a charging solution in the box, there remains a significant market for chargers sold separately. In the absence of specific data for this market, we have used the consumer panel survey carried out as part of this study to estimate its approximate size. According to respondents, 16.8% of the chargers in use were bought separately[18]. This percentage was applied in the stock model (see below), and results in an estimated 32 million units sold separately in 2018. This figure is in the same ranges as estimates in the 2014 RPA report[19] (9-14%) and in the 2015 Charles River Associates report[20] (18-34 million units). Based on the survey responses, reasons for these purchases included, in order of reported frequency, phone charger cable failure, the desire to have multiple chargers, forgetting their charger whilst travelling and losing their original charger.

On the point of decoupling, as noted above, we find that almost every phone is supplied with a charging solution in the box. In the 2014 RPA study a handful of pilots and initiatives were noted where it was possible to purchase a phone without a charger. They therefore reached the conclusion that in 2012 around 0.02% of the market was supplied without chargers, and in 2013 they estimated this had increased to 0.05%. However, research as part of this study has found no evidence on the continued success or existence of such pilots and programmes. Only one supplier, Fairphone, was noted for selling phones without a charger. They remain a very niche

[18] In response to Q A4a 'For each charger you are currently using, can you please tell me whether they were supplied together with a mobile phone? 1,377 respondents answered 'bought it separately' of 8,174 chargers in use.

[19] RPA (2014)

[20] Charles River Associates (2015): Harmonising chargers for mobile telephones Impact assessment of options to achieve the harmonisation of chargers for mobile phones

player in the market, with a very small market share. They note that they do sell chargers on their website, and estimated in interview that around a quarter of their customers also purchased chargers when purchasing a Fairphone.

Estimating the total stock of chargers

The market data presented at the start of this section was used to populate a stock model for the number of mobile phone chargers currently in use. A baseline scenario was constructed which models the stock of chargers each year based on additions (sales) and subtractions (disposals) from the stock. We modelled the charger market in relation to the following combinations of charging solution components.

Table 4: Charging solution components modelled within the stock model

EPS type	Cable types	Adaptor
USB A - standard	USB A – USB Micro-B USB A – USB C USB A – Proprietary	None USB Micro B – USB C Proprietary – USB Micro B Proprietary – USB C USB C – Proprietary USB A – USB C
USB A – fast charger (USB PD)		
USB A – fast charger (Quickcharge)		
USB C - standard	USB C – USB Micro-B USB C – USB C USB C – Proprietary	
USB C – fast charger (USB PD)		
USB C – fast charger (Quickcharge)		
No EPS	USB A – USB Micro-B USB A – USB C USB A – Proprietary USB C – USB Micro-B USB C – USB C USB C – Proprietary No Cable	

The stock model estimates the stock of mobile phone chargers as shown in the following figures, which split the stock into EPS and cable types. **Figure 6** shows the stock model estimation of the number of EPS in use from 2014-2028. This shows a total of around 800-900 million typically in use, with those with USB Type-A connectors dominating the types in use, and although USB Type-C EPS are already starting to be introduced in 2019, they only gain a noticeable share in the total stock from 2022 onwards. **Figure 7** shows the cable stock over the same period. This shows that up to 2017 the cable stock is almost entirely USB Micro B or Proprietary connectors on the device side. USB C connectors start to show in the stock from 2018 onwards. It also shows that, similarly to the EPS, the stock of cables are almost exclusively USB A on the EPS side, with USB C becoming noticeable only from 2022 onwards. This switch is made by cables with proprietary or USB C on the device side. By the end of 2028 it is estimated that USB Micro B connectors are almost redundant and USB C (device) side connectors dominate the stock, along with proprietary cables.

Figure 6: Stock model estimation of EPS types in use 2014-2028 – Baseline scenario

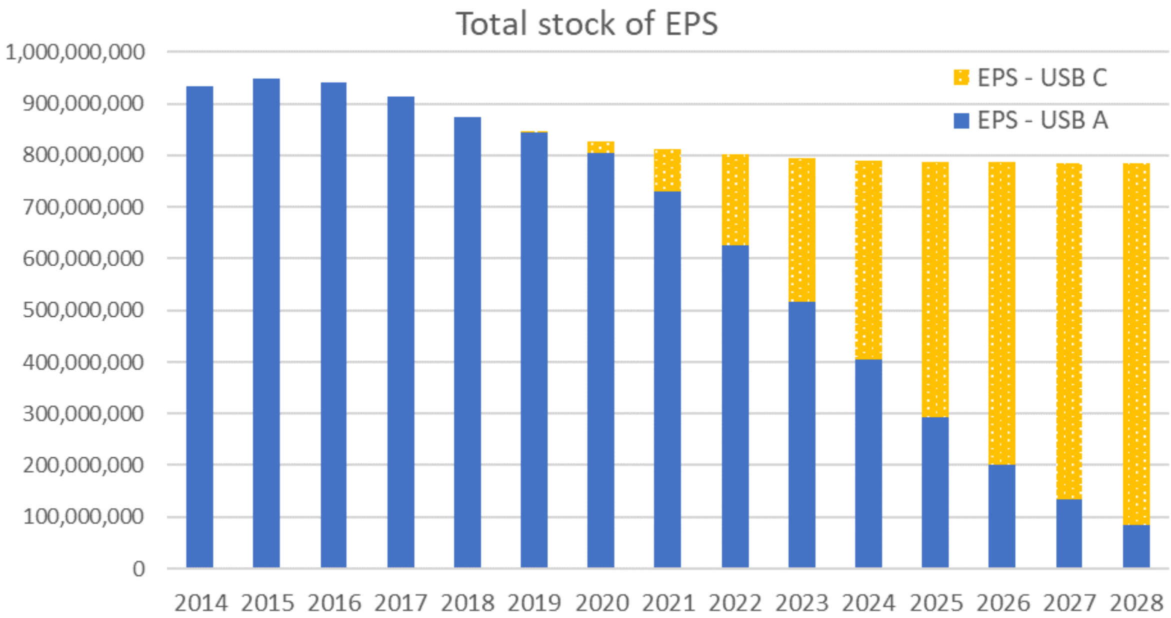
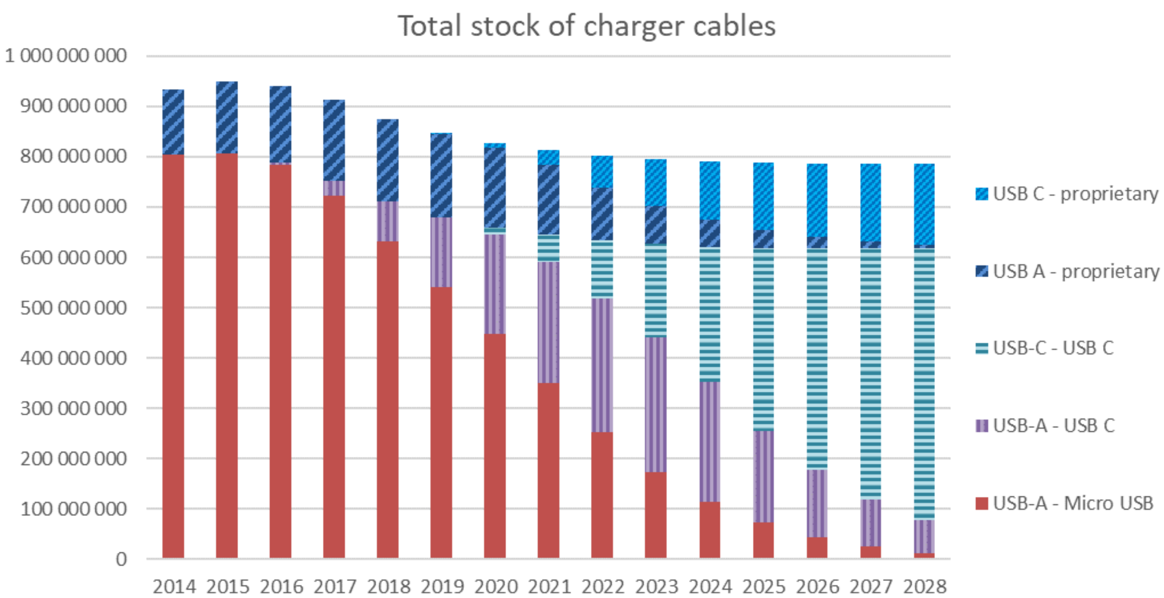


Figure 7 Stock model estimation of charger cable types in use 2014-2028 – Baseline scenario



The key assumptions underpinning these stock model results for the baseline scenario are presented below in **Table 5**. Specific assumptions relevant to the calculation of impact are presented in the relevant sections of chapter 5.

Table 5: **Key assumptions underpinning baseline scenario in stock model**

<table>
<tr><th>Additions</th><th>Disposals</th></tr>
<tr><td>

100% of phones are supplied with chargers as no significant decoupling is currently noted
Phone sales are estimated 2013-2018 from specific market data, pre-2013 estimated from Prodcom data. Apple market share 2008-2012 held at 2013 level.
Total phone sales are held at the 2018 level between 2019-2028, Apple (proprietary) market share also held to 2018 level (21.4%) between 2019-2028.
Phone sales are split per charger type as per market data 2016-2018. Prior to 2015 chargers were either USB A – USB Micro B or USB A – Proprietary.
Assumed only Apple provides proprietary charging solutions
Sales of standalone chargers (separate from phones) conform to the same types as those provided with phones in the previous year (T-1)
Based on the consumers survey sales of standalone chargers are modelled at 16.8% of the total chargers added to the stock each year.
First fast charging and USB-C (device side) solutions introduced in 2016. Growing market share since then.
Starting 2019 Apple (proprietary) starts to switch to EPS with USB C and fast charging as standard. Completed switch by 2022.
Starting 2019 fast charging EPS USB C – USB C gains market share, growing to 90% of entire market by 2024.
Remaining 10% of market assumed to cater for low-end phones that do not need fast charging. These chargers are all USB C (device side) and split between EPS USB A and USB C, converging fully on ESP USB C by 2025.
Fast-charging EPS fully converge on USB-PD fast charging standard by 2022.
EPS (standard or fast-charging) USB A – USB C cable combinations grows share to 2020, peaking at 46%. Subsequently this rapidly declines as the switch to EPS USB C gathers pace.
EPS USB A – USB Micro B share continues to decline from 50% in 2018 to 0% by 2022.

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Assumes disposal in two stages over time.
The first stage of disposal is linked to the purchase of a new phone, where there is typically a decision to be made on what to do with your existing charger. We model the timing of this stage based on the consumer survey[21], with timings of:

Year T+0: 2%
Year T+1: 6%
Year T+2: 33%
Year T+3: 25%
Year T+4: 11%
Year T+5: 9%
Year T+6: 14%

In this first stage, disposal takes one of three forms, in the following proportions – 31% disposed to e-waste (recycling) or incorrectly / 51% stored (not-used) / 18% remain in use. These ratios are based on consumer survey results[22]. See below for the e-waste / incorrect split.
The two previous assumptions are multiplied to estimate disposal methods each year. E.g. In year 2, 33% * 31% = 10.4% disposed, 33% * 51% = 16.9% stored.
Disposals to 'stored' are removed from the stock, as these are not 'in-use', but these are not counted in disposals as they did not yet enter the e-waste chain.
In a second stage, which deals with chargers that have been stored or kept in use, but are still gradually disposed of, the remainder of the stock after year 6 is assumed to be disposed in the following 4 years in equal proportions. Meaning that after 10 years all chargers are assumed disposed.
Disposals are split by charger component and type proportional to the types in original year of addition to the stock.
All disposals (at first or second stage) are split into either recycling or incorrect disposal (general waste). In 2019 this proportion is 75:25. The recycling rate increases by 1% point per year to 2028, consistent with targets in WEEE Directive. It is also 1% lower each year prior to 2019.

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</table>

3.4 The market for chargers of other portable electronic devices

As noted above (section 3.1), an initiative for a common charger could potentially also be envisaged to cover portable electronic devices other than mobile phones. In this section, we briefly discuss the charging profiles of certain other devices[23] (to assess the extent to which these are similar to mobile phones), summarise key market trends for such devices, and consider the extent to which they are typically sold with or without chargers (decoupling). More detailed information on each of these elements is available in Annex D.

Charging profiles

The current (measured in ampere), voltage (measured in volts) and power (measured in watts) are the key parameters that define any electrical circuit. The power combines the voltage and the current (P = A x V), so this is the key metric of interest when comparing electric devices. The current flow defines the section of the connectors and wires. It generates heat that must be dissipated, otherwise the component can be combusted. Connectors of tablets, e-readers, wearables and cameras can also be used for communication between the device and a computer. Therefore, the connector (e.g. USB cable) must be also compliant with communication protocols to guarantee a safe transmission of data.

Mobile phones' charging power typically ranges between 5W and 18W if they include USB Power Delivery (PD) technology. Devices with similar characteristics include, for instance, e-readers, wearables, and cameras, as illustrated in **Table 6**. Laptops, however, require more power, which poses technical challenges when it comes to sharing the EPS with a mobile phone. USB PD offers enough power to charge laptops. However, given that mobile phones typically do not need this much power, the chargers included in the box with phones do not provide the power that laptops need. This means that these chargers can charge a laptop, but only very slowly. On the other hand, the chargers included in the box with laptops could charge mobile phones (provided they come with the right connectors) using only the power required by the mobile phone and ensuring a safe charge for both the user and the device. As a consequence of this, if laptops were to be included within the scope of the new regulation or voluntary agreement, the mandated common charger would need to provide higher power capacity than what mobile phones typically need.

Table 6: Typical charging characteristics of portable electronic devices

Device	Current	Voltage	Power
Smartphones	1A – 2.5A	5V – 12V	5W – 18W

[21] Based on consumer survey question 'D1 Over the course of the last 5 years, how often have you purchased a new mobile phone for personal use?'

[22] Based on consumer survey question ' D3. How do you usually dispose of mobile phone chargers you are no longer using?' See also Table 13.

[23] The selection of devices within the sample assessed by this study was made based on a range of factors, including their relevance and the availability of data. Certain other devices were mentioned during the consultations, but excluded from the analysis for different reasons. For example, GPS navigation devices were relatively common a few years ago, but have experienced a rapid decline due to intensifying competition from other developers of mapping technologies, prompting many major retailers to stop selling these devices. On the other hand, certain types of rechargeable household appliances could potentially be relevant to consider, but the very wide variety of such devices, and the dearth of sufficiently granular data on them, meant it was not feasible to provide a meaningful analysis within the scope of this study, which had to concentrate on the those devices where the analysis was likely to add the most value.

Device	Current	Voltage	Power
Laptops	1.5A – 3A	19V – 20V	30W – 65W
Tablets	1A – 3.25A	3.76V – 20V	9.36W – 65W
E-readers	0.5A – 2.5A	3.7V – 5.35V	10W – 12.5W
Wearables	0.1A – 2A	3.7V – 9V	0.7W – 10W
Cameras	0.2A – 1.89A	3.6V – 8.4V	1W – 10W
Sport cameras	1A – 3.25A	3.9V – 20V	2.4W – 65W
Videogame devices	0.8A – 3A	3.65V – 15V	3W – 20W

Source: *Ipsos's own research (2019) based on a sample of 87 products.*

Another challenge to ensure interoperability between the charging solutions of mobile phones and other devices is the connector at the device end. While many of the devices in the sample we looked at use USB micro-B or (less frequently) USB Type-C connectors, proprietary connectors are relatively common in some categories, in particular laptops, tablets, and wearables. During consultations, industry representatives mentioned that certain devices require connectors with specific characteristics to meet the functions the device is designed for or to fit within confined spaces. This is the case, for instance, of small-size wearables that are submergible, or devices that are intended to function in extreme environments. The form of the device also limits the type of connector it supports. Examples provided by interviewees where USB Type-C (or other types of USB) may not be suitable include: health devices, such as hearing aids, household appliances, or some Internet of Things (IoT) devices used in agriculture. These devices frequently use proprietary connectors and, more recently, wireless chargers. A wireless charger is generally composed of a platform and a cable with a USB connector at both ends of the cable. The device, for instance a smartwatch, is charged while placed on this platform.

A variety of connectors, in fact, is used in battery-operated devices other than smartphones. An overview of the different types of connectors used by different types of devices is presented in **Table 7**.

Table 7: Types of connectors used in other portable devices

Device	USB micro-B	USB Type C	Proprietary solutions	Other USB / wireless
Laptops	Laptops cannot be charged with USB micro-B.	A small number of models in our sample (3 out of 11) have USB Type C connectors.	Most of the laptops in our sample (8 out of 11) are based on proprietary solutions.	N/A
Tablets	A small number of models in our sample (3 out of 10) have USB micro-B connectors.	A small number of models in our sample (3 out of 10) have USB Type C connectors.	Most of the tablets in our sample (4 out of 10) are based on proprietary solutions.	N/A

Device	USB micro-B	USB Type C	Proprietary solutions	Other USB / wireless
E-readers	Nearly all the e-readers in our sample (7 out of 8) have USB micro-B connectors.	Only one e-reader in our sample has a USB Type C connector.	None of the e-readers in our sample uses proprietary solutions.	N/A
Wearables	Nearly half of the wearables in our sample (7 out of 15) have USB micro-B connectors.	Only one wearable uses a USB Type C connector.	Some wearables in our sample (6 out of 15) use proprietary solutions.	One wearable uses a wireless charger
Cameras	Most of the cameras in our sample (9 out of 12) have USB micro-B connectors.	Only one camera in our sample uses a USB Type C connector.	A small number of models in our sample (2 out of 12) have proprietary solutions.	N/A
Sport cameras	Nearly half of the sport cameras in our sample (5 out of 11) have USB micro-B connectors.	Some sport cameras in our sample (4 out of 11) use USB Type C connectors.	None of the models in our sample uses proprietary solutions.	A small number of models in our sample (2 out of 11) use USB mini-B connectors.
Videogame devices	Most of the videogame devices in our sample (5 out of 8) have micro B connectors.	One device uses a USB Type C connector.	One of the devices in our sample has a proprietary connector.	One model uses a USB mini-B connector.

Source: *Ipsos's own research (2019) based on a sample of 87 products.*

Laptops are the type of device with the highest share of proprietary charger connectors among all the types of portable devices analysed in this study, although USB Type-C is used in a small number of models. This may be due partly to the fact that, according to some of the stakeholders interviewed for this study, there are technical issues related to the inclusion of USB Type-C chargers on laptops, as certain models need more than 100W, which is the maximum power provided by USB PD.

Market trends for other portable devices

In the absence of comprehensive and robust sales data for portable electronic devices, market trends were evaluated by using alternative sources. Market data for devices other than mobile phones was obtained from a variety of datasets on shipments and imports. Particularly data from Comtrade describing imports into the EU from the world should provide a good indication of the relative volumes of the markets for different portable devices and overall trends, as nearly all such devices are manufactured overseas (usually in Asia).[24] In total, we estimate that at least 335 million portable electronic devices corresponding to the categories listed above were sold in the EU in 2018. This includes a number of devices for which sales have been

[24] For example, see: The Economist (2018). *China's grip on electronics manufacturing will be hard to break*. Accessed at https://www.economist.com/business/2018/10/11/chinas-grip-on-electronics-manufacturing-will-be-hard-to-break on 2

growing in recent years (including wearables and digital cameras), as well as some for which they have been in decline (including laptops, tablets and e-readers). For further details on specific devices, trends and data sources, please refer to Annex D.

Table 8: Estimated sales of other portable electronic devices

Type of device	**Estimated sales in the EU (units), latest available year**	**Sales trend, latest three years available**[25]
Tablets	20.7m	↘
E-readers	16.2m	↘
Wearables	116m	↗
Digital cameras	54.2m	↗
Sport cameras	3.2m	↑
Videogame devices	52.1m	↗
Laptops	74.4m	↘
TOTAL	**336.8m**	

Source: Estimates based on various sources, including data from Comtrade and Statista. For details see Annex D.

Decoupling

From an analysis of a sample of devices of different types, it was confirmed that decoupling (i.e. the sale of devices without a charger) is rare among larger devices. All the laptops considered in the market analysis were sold with an EPS and cable included in the box. Industry stakeholders stressed that consumer convenience, technical, safety and liability concerns were the reasons for this. Similarly, all the tablets in the sample analysed for this study were sold together with a charging cable and EPS, regardless of the type of connector (proprietary, USB micro-B or USB Type-C). Digital cameras and battery-operated videogame devices were also sold together with the EPS and the charging cable.

On the contrary, nearly all small devices, including action cameras, e-readers, and wearables were sold only with a charging cable, but without an EPS. In fact, these devices were sold together with an EPS only when a proprietary connector was used, whereas if they had a USB-based connector, the EPS was normally not included in the box.

During interviews, manufacturers underlined how for certain products, finding a charger in the box is part of the consumer experience, especially for high-end products; they argued that mandating decoupling could potentially lead to poor consumer experience, in addition to safety-related problems. In addition to these considerations, one industry stakeholder stressed that decoupling would imply reforming the way safety tests are currently carried out, as devices are normally tested together with their chargers; not providing a charger with a device could mean that the scope of testing could be expanded, resulting in longer time before a product can be commercialised and higher financial costs.

[25] ↑ indicates an increase above 20%, whilst ↘ an increase up to and including 20%. Similarly, ↘ indicates a decrease of 20% or less.

3.5 The consumer perspective

A number of issues around the current fragmentation of mobile phone chargers and, more broadly, of chargers for different electronic devices were raised by the consumer associations which participated in the Public Consultation conducted by the European Commission; similar issues were also highlighted in a series of interviews with representatives of consumer organisations that were contacted to provide their views on the current situation.

Nearly all the consumer associations involved in the study stressed that the presence of different types of connectors and chargers is inconvenient for mobile phone users. Having different chargers for different electronic devices, in fact, was indicated as a source of confusion, especially for older people or people affected by disabilities. It was underlined how the absence of clear labelling may make it hard to identify the differences among chargers, or to understand whether a charger is suitable for a given device. Clearer labelling was suggested as a measure to distinguish chargers with different charging features (e.g. by defining a limited number of types of chargers based on their power output and/or specifications, and labelling them accordingly).

Consumer organisations seemed to agree that, at present, most electronic devices, and in particular mobile phones, are sold exclusively with a complete charger in the box. This was said to narrow consumer choice, as well as making consumers incur higher financial costs. Further to this, some consumer organisations highlighted that most consumers need more than one charger for the same device (e.g. for home and for the workplace), and the lack of harmonisation forces consumers to purchase new chargers separately, as older chargers are not suitable for newer devices. Consumer associations stressed that this resulted in accumulating old chargers at home or at the workplace. Consumer organisations also raised issues related to the environmental aspects linked to the current fragmentation, and to risks from substandard chargers that do not comply with relevant safety standards (for more on these issues see sections 3.6 and 3.9 below).

The majority of the EU citizens who participated in the European Commission's Public Consultation on mobile phone chargers[26] were dissatisfied (41%) or very dissatisfied (22%) with "the current situation regarding mobile phone chargers and their seamless interconnection" (similar proportions were (very) dissatisfied with the situation regarding chargers for other portable electronic devices). 76% agreed (a little under half of them "strongly") that the current situation results in inconvenience for mobile phone users. Types of inconvenience reported by a majority of respondents were the need for users of mobile phones and/or other portable electronic devices to have several different chargers, which occupy space and/or can lead to confusion; and that it can be difficult for mobile phone users to access a suitable charger when away from home, at work, travelling, etc. Nearly 70% also felt the current situation results in financial costs for mobile phone users, while 62% cited performance issues (regarding the time it takes to charge phones). On the other hand, 32% of respondents agreed that the current situation gives consumers the ability to choose from a wide range of charging options.

<u>Results of the consumer panel survey</u>

The sections below highlight the main findings from the survey analysis. Unlike the Public Consultation, the survey was undertaken with a broadly representative sample of consumers in ten EU Member States, and therefore provides a good indication of

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[26] The Consultation drew a total of 2,850 responses, of which 2,743 (96%) were from EU citizens. For further details see Annex B.

consumers' actual ownership and use of mobile phone chargers,[27] and of the extent to which the issues and problems reported by those who tend to feel most strongly about them (and therefore chose to take part in the Public Consultation) are felt among consumers at large.

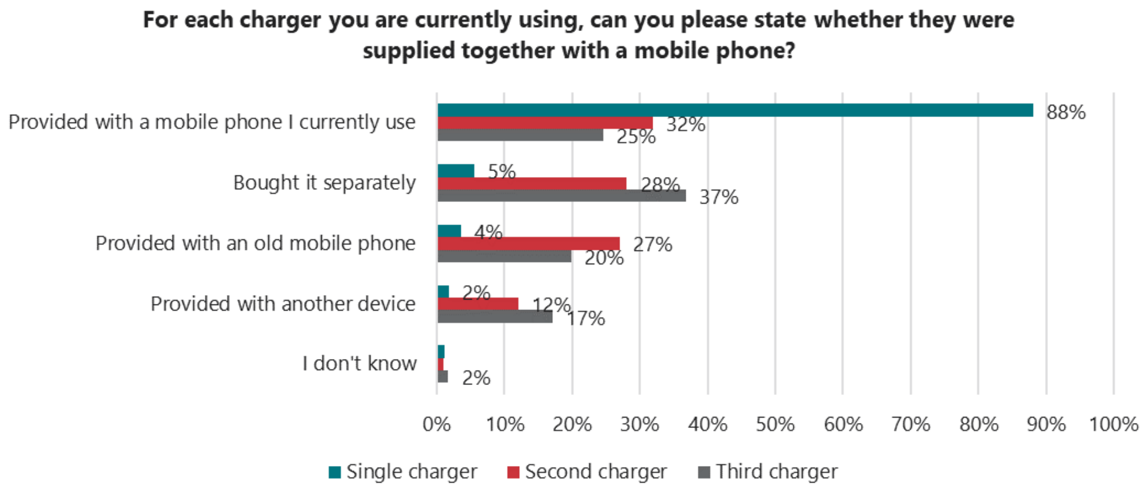
How many mobile phone chargers do consumers own and use?

In summary, the results of the consumer panel survey suggest that the average consumer owns around three mobile phone chargers, of which they use two on a regular basis. A little under half of consumers only use a single charger, while the remainder use two or more.

Across all respondents, the average number of chargers *owned* by all respondents was three, which is consistent for both iPhone and non-iPhone users. When disaggregating these results by age, 18 to 24-year olds owned an average of four chargers, compared to three chargers for respondents in all other age categories. Survey respondents also reported *using* an average of two chargers which implies that on average, one changer is left unused. There was significant variance in this data, with a few respondents reporting to own as many as 25 chargers.

Survey respondents were also asked about how they *acquired* their current mobile phone chargers. For participants who used only one charger regularly (48% of all respondents), 88% responded that it was provided with their current mobile phone, with only 5% of chargers bought separately (as shown in Figure 8). Second and third chargers in use were more often supplied separately (28% and 37% respectively) or from a previous mobile phone or device (20% and 17% respectively).

Figure 8: The way in which single and multiple chargers are supplied



Source: Ipsos consumer survey (2019), N = 5,002

How do consumers use mobile phone chargers?

In summary, a little more than a third of consumers use their mobile phone charger to charge other mobile phones and/or other electronic devices (in particular tablets).

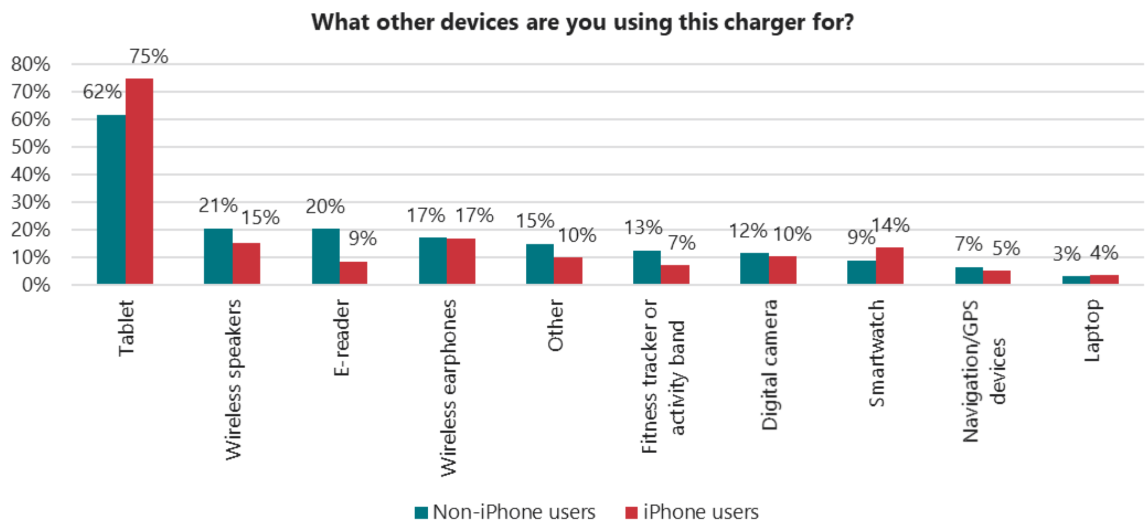
[27] Please note: The consumer panel survey focused on *mobile phone* chargers, which were defined as: "A device used to charge the battery of a mobile phone, typically consisting of an external power supply (charging block) and a cable to connect the power supply to the mobile phone (also sometimes called cable assembly)". Throughout this section, all references to "chargers" refer to mobile phone chargers, not chargers of any other portable electronic devices.

When doing so, slightly over half of respondents clarified they use both the cable and the external power supply together, with the remainder only using one or the other.

While 63% of survey respondents reported to only use their charger(s) to charge one specific phone, 37% also use their charger to charge other mobile phones, electronic devices or both. iPhone users had an increased likelihood to do this compared to non-iPhones users (39% and 36% respectively), which may suggest that iPhone users tend to charge other Apple devices. Approximately 41% of all respondents aged 18 to 44 charge other mobile phones, electronic devices or both, but this figure falls with age, decreasing to 29% for respondents aged 65 and above.

For those respondents who are using their mobile phone charger to charge other electronic devices, tablets were the most popular alternative devices (65%) followed at a considerable distance by wireless speakers (19%) and E-readers (18%). Further detail is provided in Figure 9 below. The proportion of respondents' mobile phone chargers used to charge tablets increases with age, from 45% to 65% (18 to 24-year olds and 65 years and above respectively). The youngest age group shows the largest proportion of chargers used for wireless speakers and headphones (36% and 34% respectively) compared to those aged 65 and above which show digital cameras and navigation/GPS devices as the most commonly charged alternative (15% and 14% respectively).

Figure 9: Other devices charged with respondent's current mobile phone charger

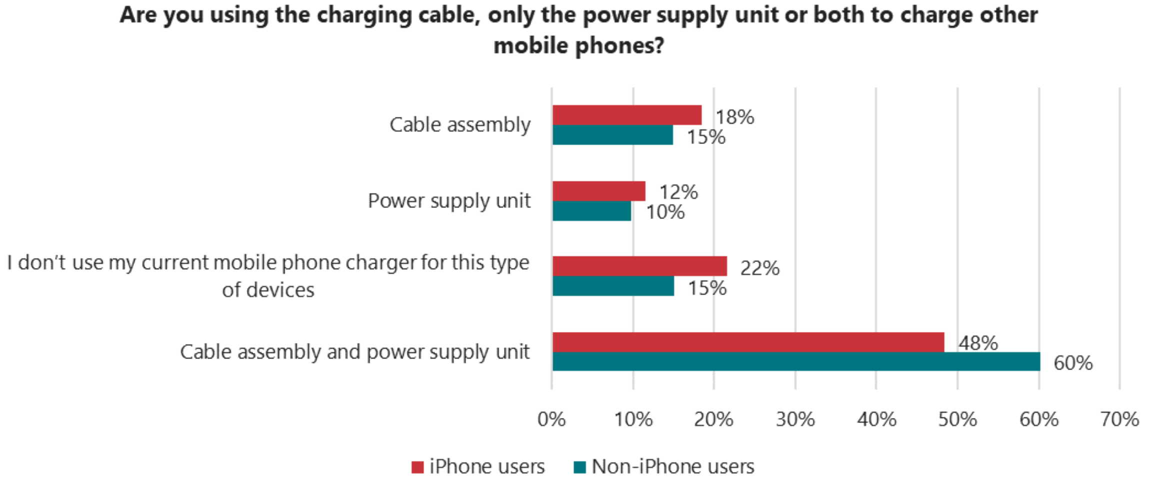


Source: Ipsos consumer survey (2019), N = 1,057

The majority of respondents (58%) using their mobile phone charger to charge other mobile phones (Figure 10) used both the cable assembly and external power supply unit. Although there was no trend by age, non-iPhone users were more likely than iPhone users to use both the cable assembly and power supply (60% vs 48%) whilst iPhone users were more likely to use either the cable assembly or power supply unit only (12% and 19% vs 10% and 15% respectively).

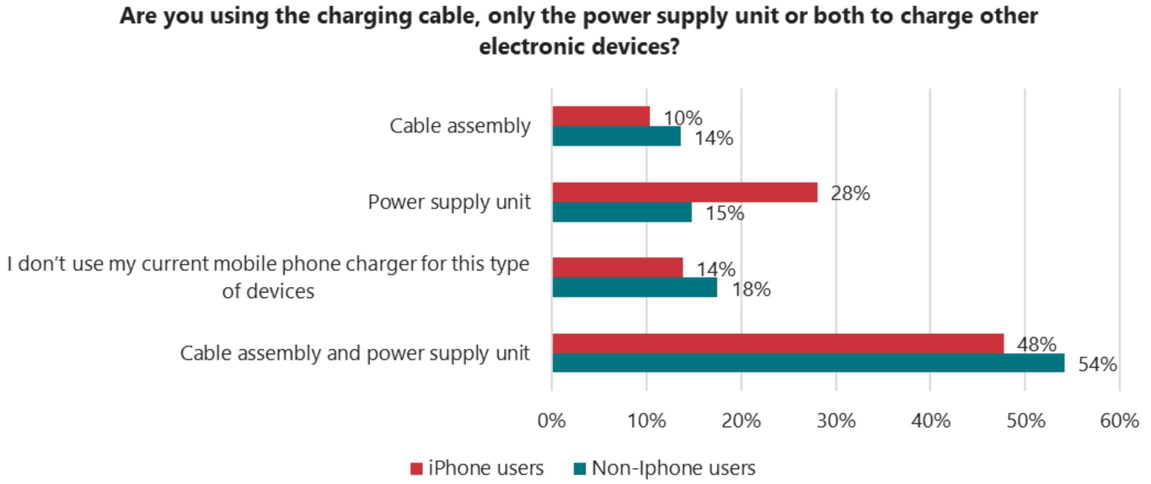
Similarly, when charging other electronic devices (Figure 11), most respondents (53%) used both the cable assembly and power supply unit. The proportion of respondents doing this increased with age (from 44% to 59% for 18 to 24-year olds and 65-year olds and above, respectively). iPhone users were more likely to use only the power supply unit to facilitate charging compared to non-iPhone users (28% vs 15%), and conversely less likely to use only the cable assembly (10% vs 14%).

Figure 10: Method used to charge other mobile phones



Source: Ipsos consumer survey (2019), N = 1,867

Figure 11: Method used to charge other electronic devices



Source: Ipsos consumer survey (2019), N = 1,867

From the perspective of non-iPhone and iPhone users, 27% and 25% of respondents reported that charging other mobile phones with their primary mobile phone charger resulted in a significant or slight reduction in its performance. Reductions in charging performance were more frequently reported by those aged 18 to 44-years old.

In contrast, 35% of non-iPhone users and 30% of iPhone users reported no impact on charging performance and said that the charger provided the same level of performance when charging other mobile phones. However, 19% and 32% of survey participants respectively (driven by those aged 55 and above) stated that there was no observable difference in charging performance when the mobile phone was from the same manufacturer. It must also be noted that 20% and 13% of users respectively did not know the effect of the charger on charging speed when charging other mobile phones.

Problems with chargers experienced by consumers

Participants in the consumer survey were also asked whether they had experienced any problems when using a mobile phone charger in the 24 months prior to the survey. 84% of respondents reported having experienced at least one of the different types of problems included as response options (see below). The most commonly cited problems (experienced at least once by around half of respondents) were: having too many chargers taking up space at home and/or at the workplace; not being able to charge mobile phones as fast with other chargers; not being able to charge other electronic devices; and not being able to charge new phones with old chargers. Fewer respondents (around a third) reported being provided a charger when they would have preferred to keep using their old one; problems with access to a compatible charger; confusion regarding which charger to use for which phone and/or other device; and safety issues. However, typically only a minority of respondents (between 35% and 50% of those who reported having experienced each of these issues, or around 15% to 20% of all survey respondents) felt that these were serious problems, i.e. had caused them significant issues.

Although not directly comparable (due to the differences in questions, response options, and respondents), the consumer panel survey points to broadly similar sources of inconvenience as the Public Consultation (see the beginning of this section). However, these are deemed less serious by survey participants than by respondents to the Consultation:

- While 45% of EU citizens who responded to the Public Consultation felt that "Mobile phone users or households need to have several mobile phone chargers, which occupy space and/or can lead to confusion" was a *serious* problem, only 21% of consumer panel survey participants reported that having too many chargers taking up space in my home or workplace had caused them *significant* issues, and only 17% reported having experienced *significant* issues due to confusion about which charger to use for which device.

- While 49% of EU citizens who responded to the Public Consultation identified "It can be difficult for mobile phone users to access a suitable charger when away from home, at work, travelling, etc." as a *serious* problem, only 19% reported having experienced *significant* issues due to needing to charge their phone, but the available chargers being incompatible with it.

Figure 12 overleaf presents aggregate responses for all consumer panel survey respondents who had experienced problems in the 24 months prior to the survey (with varying frequencies). These can be grouped into **five types of problems** (the first four of which relate to different aspects of inconvenience, while the final one is about safety):

- Inability to charge certain devices (as fast) with certain chargers: Around half of all respondents (53%) stated that they could not charge their mobile phones as quickly using other chargers, that they could not charge other electronic devices with their (phone) charger (49%), and/or that they could not charge their new phone with their old charger (46%)

- Too many chargers: 53% of respondents reported problems due to having too many chargers taking up space in their home or workplace, while 40% were provided with a new charger with a new phone when they would have preferred to keep using their old one.

- No access to a compatible charger: 38% of respondents reported having been in a situation where they needed to charge their phone, but the available chargers where not compatible with it.

- Confusion about which charger works with what: 30% of respondents have been confused about which charger to use for which mobile phone, while 35% have been confused about which charger to use for which other portable electronic device.

- Product safety issues: 31% reported a charger became unsafe to use.

The most commonly cited problems to be either experienced almost every day or on numerous occasions included not being able to charge a new phone with an old charger (18%), having too many chargers at home and/or the workplace taking up space (16%), and not being able to charge other electronic devices with a charger (15%).

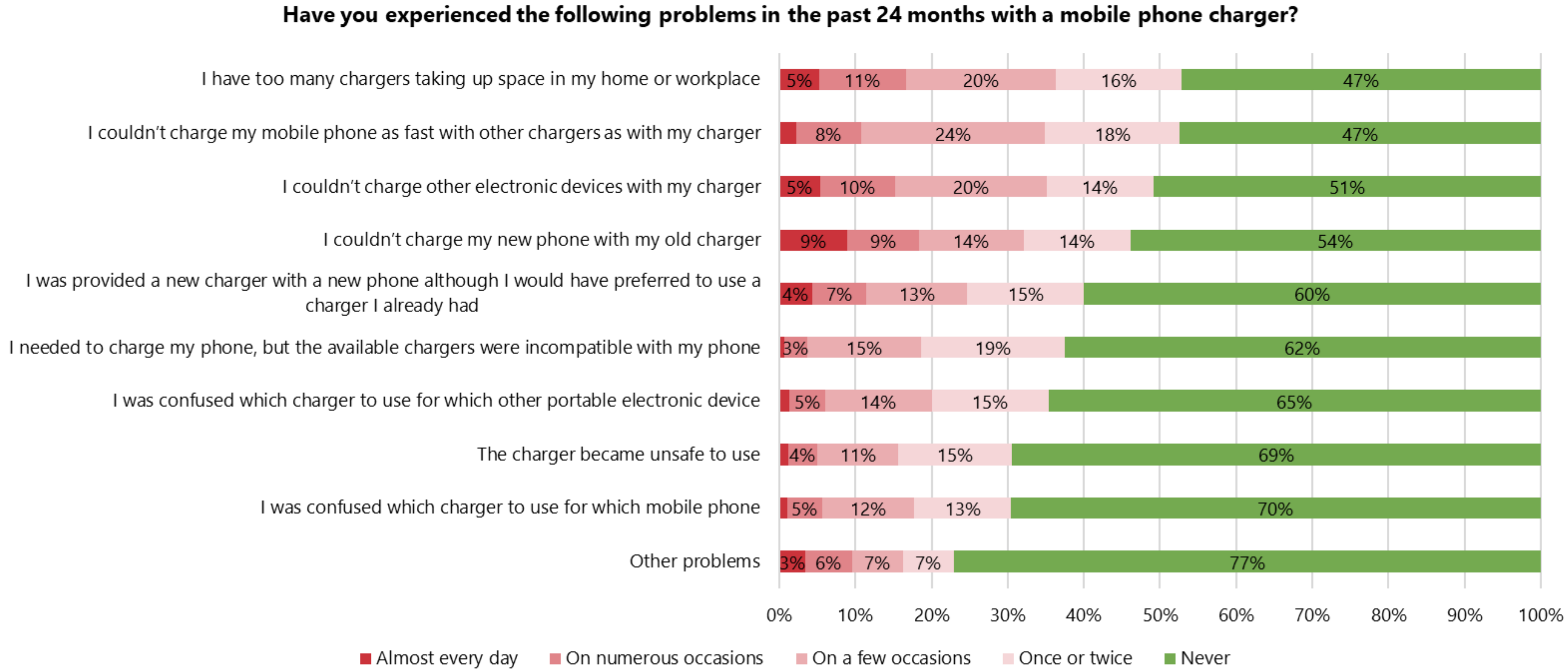
When analysing these issues at a model level, iPhone users reported a more significant detriment (the issues presented caused significant issues from time to time or on a regular basis) across all three issues outlined above (68% vs 61%, 60% vs 48% and 53% vs 48%) compared to non-iPhone users. The three issues which showed the largest difference amongst the two types of users were: the respondent was confused about which charger to use with other mobile phones, the respondent could not charge their mobile phone as fast with other chargers and the respondent was confused about which charger to use with other electronic devices (48% vs 40%, 60% vs 48% and 56% vs 47%).

A higher percentage of iPhone users reported that available chargers were incompatible with their phone and that they could not charge other electronic devices with their charger (48% vs 35% and 58% vs 47% respectively). It seems likely that this is due to the fact that Lightning connectors offer less interoperability with non-Apple products than other connector types. Overall, a higher proportion of iPhone users who took part in the survey reported having experienced eight out of the ten issues forms of inconvenience in the past 24 months.

When respondents rated the seriousness of these problems (as shown in Figure 13), the problems perceived to cause the highest degree of inconvenience (those problems that caused significant issues from time to time or on a regular basis) were that respondents could not charge their mobile phone as fast with other chargers, they could not charge their new phone with their old charger and that they had too many chargers taking space in their home or workplace (1,090, 1,075 and 1,068 respectively). When solely analysing problems that caused a significant issue on a regular basis, the inability of users to charge their new phone with their old charger and the inability to charge other electronic devices with their charger were the most prominent issues faced by all consumers.

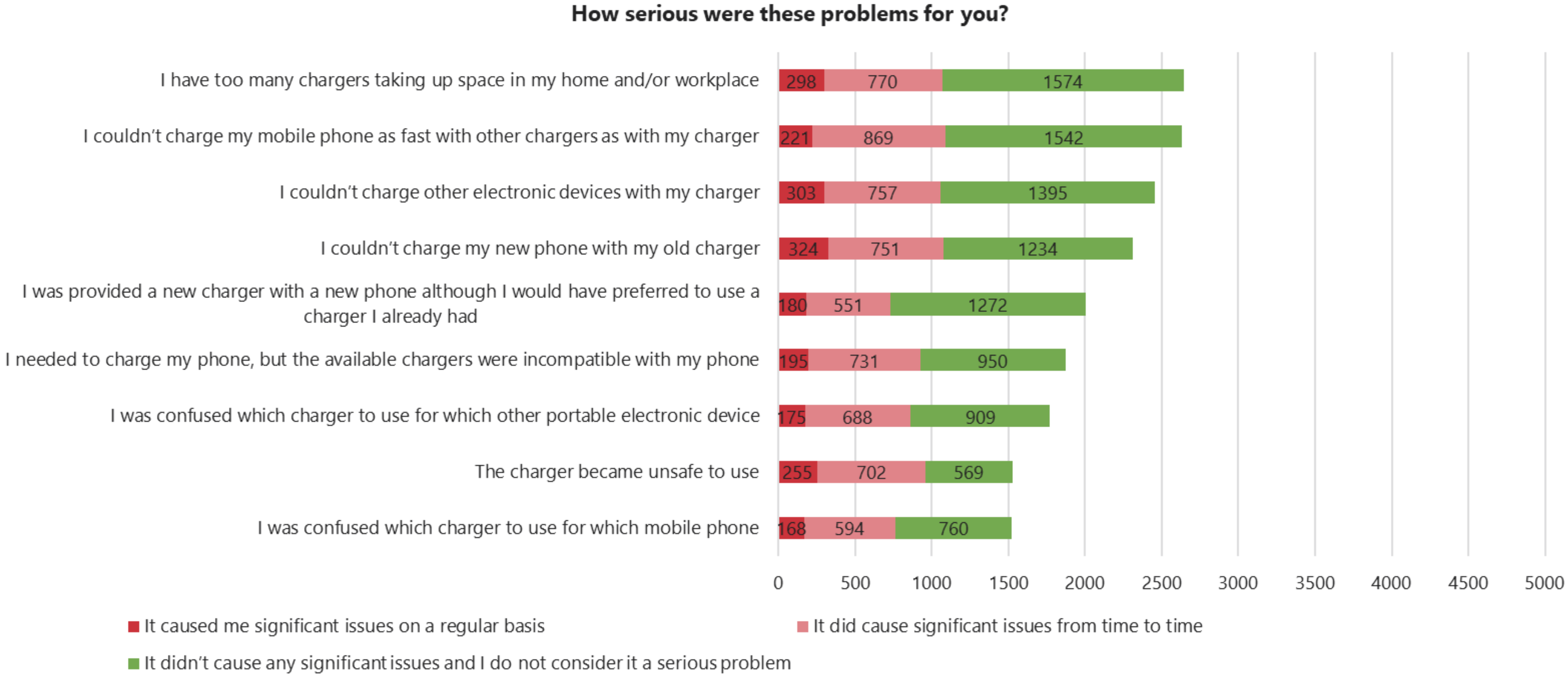
At a disaggregated level, iPhone users reported the issues that caused the highest degree of inconvenience were that they could not charge other electronic devices with their charger, only incompatible chargers were available when they needed to charge their phone and the charger eventually became unsafe to use (253, 250 and 243 responses respectively). Again, some of these could be due to a lack of interoperability for iPhone charges if consumers cannot use it to facilitate charging of other devices or struggle to find a compatible charger when needed. In comparison, non-iPhone users reported that the primary reasons leading to some form of inconvenience were that they could not charge their mobile phone as fast with other chargers, they couldn't charge their new phone with their old phone, and that they had too many chargers in their home or workplace (853, 850 and 830 respectively). This suggests inconvenience faced by non-iPhone consumers when purchasing a new phone which results in a lack of interoperability and an individual level stock pile of chargers.

Figure 12: Share of all respondents experiencing problems with a mobile phone charger



Source: Ipsos consumer survey (2019), N = 5,002

Figure 13: Number of respondents by seriousness of problem reported



Source: Ipsos consumer survey (2019), N = 1,564 – 2,624

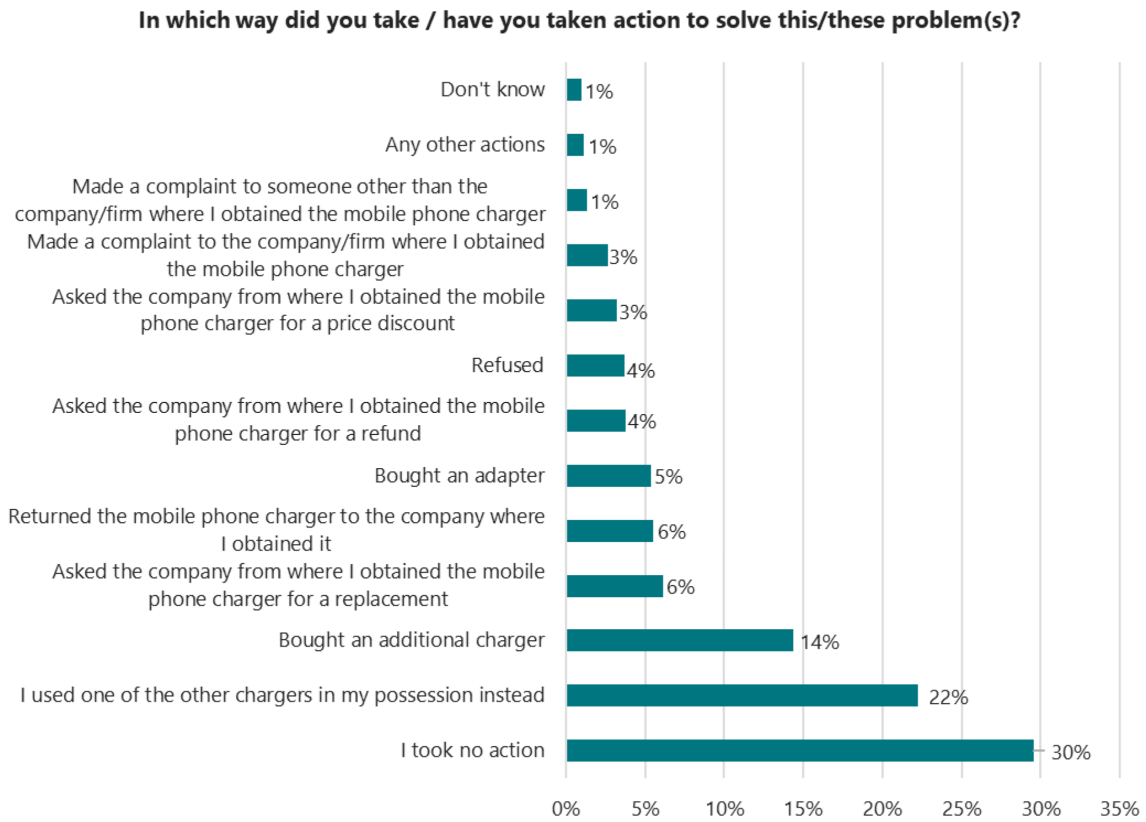
Actions taken to address problems, and costs incurred

As part of the survey, respondents who experienced one or more of the issues discussed above were also asked what (if anything) they had done to resolve / address the issue(s), and any costs incurred (in terms of time and money). The responses suggest that these costs can be non-negligible, although the results need to be interpreted with a degree of caution due to the relatively small number and high variability of responses, and the fact that the questionnaire did not distinguish between the actions taken / costs of the different types of problems (since asking about the actions taken to address each type of problem separately would have resulted in an excessively long questionnaire).

Figure 14 outlines the actions taken by consumers to resolve the problems they encountered when using a mobile phone charger. 30% of participants who experienced a problem with their mobile phone charger took no action to alleviate the issues raised previously. Respondents aged 35 and over were more likely not to take any action. The most commonly cited reasons for taking no further action was that either the participant felt that the problem wasn't serious enough (50%) or they felt that it would take too much time and effort (19%).

The most common action taken by respondents who took some form action to resolve the problems reported were that they either used another charger that they already owned, or bought an additional charger (22% and 14% respectively). A slightly higher proportion of non-iPhone users used an alternative charger in their possession (23% vs 18%) when compared to iPhone users.

Figure 14: Action taken to resolve problems experienced with mobile phone chargers



Source: Ipsos consumer survey (2019), N = 4,180

Respondents were also asked whether they had incurred any costs as a result of the problems they reported when using mobile phone chargers. 18% (736 responses) of those facing issues said this was the case (15% of all survey respondents), resulting in an average cost of €35. Costs reported by consumers included the costs of telephone calls, replacing or repairing goods and lost earnings due to not being able to work.

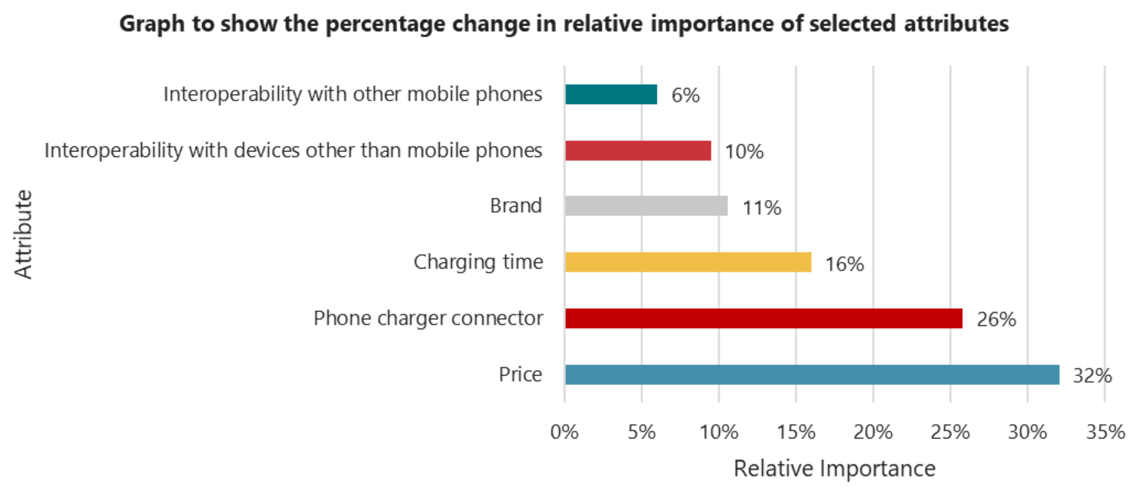
Of those respondents that had experienced any of the problems presented within the survey, 20% reported that they had spent part of their free time attempting to resolve these charger issues (16% of all survey respondents). Across respondents who provided an estimation of the time spent resolving these issues (559), the average was 6 hours. However, the data is heavily skewed by a few responses (with 25 respondents reporting having spent 30 hours or more resolving these problems). This generated a mode of 0.7 hours and a median value of 1.5 hours across respondents.

Relative importance of interoperability when compared to other product attributes of mobile phone chargers

A conjoint module[28] was included in the consumer survey to investigate the relative importance of different product attributes of mobile phone chargers. This allowed the study team to investigate how much consumers value certain product attributes (when purchasing a stand-alone charger).

The results of the conjoint experiment demonstrated that price and the type of connector at the EPS and phone end were the most important attributes for consumers when choosing what mobile phone charger to buy. Interoperability with other mobile phones and other devices were the least important of the six attributes included in the conjoint experiment. This suggests that, when purchasing chargers separately, consumers typically have a specific device in mind, and the ability to use chargers across different devices is only a minor factor in their decision-making.

Figure 15: Relative importance of product attributes – mobile phone chargers



[28] The conjoint experiment undertaken provided relative utilities for the following product attributes: Interoperability with other mobile phones; Interoperability with devices other than mobile phones; Brand; Charging time; type of phone charger connector at EPS and phone end; Price. This allows to estimate market shares for a charger with any combination of these attributes. See: https://en.wikipedia.org/wiki/Conjoint_analysis

Table 9: Conjoint analysis comparison scenarios

Attribute	Most favourable option	Least favourable option
Interoperability with other mobile phones	Can charge other phones ensuring same performance	Can only charge phone that it was originally intended to charge
Interoperability with devices other than mobile phones	Can be used to charge any other device	Cannot be used to charge other devices
Brand	Same brand as my phone	A brand I haven't heard of
Charging time	40 minutes	240 minutes
Type of phone charger connector at EPS and phone end	USB A charger and USB micro-B phone connector	USB C both charger and phone connector
Price	€10	€50

Source: Ipsos consumer survey (2019), N = 4,906

<u>Consumer value of interoperability with other mobile phones</u>

Using the results of the conjoint module, the premium that consumers are willing to pay for a mobile phone charger with varying degrees of interoperability and performance can be modelled. In order to attribute a monetary value for varying degrees of phone charger interoperability and performance, an initial baseline scenario was created for each connector type, as outlined in the table overleaf.

Each baseline for scenario 1 across connector types initially assumes a common set of attributes and that the phone charger can only charge the phone that it was originally intended to charge and cannot charge other phones. An improvement was then made to make the charger *interoperable*, meaning that it can now charge other phones, but with a reduced charging speed. A percentile monetary premium can then be estimated by adjusting the price of the charger to maintain customer preference shares as outlined in scenario 1 of each connector type.

Scenario 2 assumes that the initial base line was that the charger is interoperable, i.e. can charge other phones, but with a reduced charging speed. An improvement is then made to ensure identical *performance*, meaning that the mobile phone charger can now charge other phones ensuring the same charging speed. A similar method can then be used as described above to ascertain the monetary value placed on varying levels of interoperability and performance by consumers. The results of this are summarised below.

Typical charger with a Lightning connector at the device end:

- Consumers valued an improvement from no interoperability to interoperability at a price premium of 8%.

- Consumers valued an improvement from interoperability to identical performance at a price premium of 4%.

Typical charger with a USB micro-B connector at the device end:

- Consumers valued an improvement from no interoperability to interoperability at a price premium of 20%.

- Consumers valued an improvement from interoperability to identical performance at a price premium of 13%.

Typical charger with a USB Type C connector at the device end:

- Consumers valued an improvement from no interoperability to interoperability at a price premium of 12%.

- Consumers valued an improvement from interoperability to identical performance at a price premium of 8%.

In other words, based on the "typical" prices that were assigned to the different "typical" chargers (which are in line with current prices for complete OEM chargers – EPS and cable – in the online shops of the major mobile phone manufacturers), the conjoint experiment suggests that, when purchasing a standalone charger, **consumers would be prepared to pay around €3 more for a charger that is able to charge other phones** (compared with one that can cannot charge any other phones). However, it is important to reiterate that **this price premium corresponds with a hypothetical improvement from *no* interoperability to *full* interoperability, which is not the case in practice**. Instead, as discussed in detail elsewhere in this report, the degree of interoperability between different chargers and phones is already quite high (i.e. the hypothetical case used as a basis here, of a charger that can only charge the phone it was originally intended to charge, does not exist in reality). Even cables with a Lightning connector can be used for other iPhones, and the corresponding EPS – with a different cable – can be used to charge most other phones. Therefore, the price premium consumers would be willing to pay to go from *limited* (and in many cases quite high) interoperability to *full* interoperability is almost certainly lower than €3 (but the exact value cannot be modelled based on the data at our disposal, as this would have required an even more complex set-up of the conjoint experiment). Similarly, the actual price premium for achieving the same charging speed across all phones is likely to be lower than that estimated (around €2 based on the scenarios shown below), since *some* chargers can already charge *some* phones at the same speed as the one they were originally intended to charge.

Table 10: Conjoint analysis – price premium for enhanced interoperability and performance of chargers

Charger Attributes		**Lightning charger**		**Micro-USB charger**		**USB C charger**	
Connector at the device end		Lightning		USB micro-B		USB Type-C	
Common attributes		• Connector at the EPS end: USB Type-A • Brand: Same brand as the consumer's phone • Charging time: Can be fully charged in 120 minutes • Interoperability with portable devices other than mobile phones: Can be used to charge small devices such as smart watches and compact digital cameras					
Price		€40		€15		€25	
Scenarios		Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Interoperability with other mobile phones	**Baseline**	Can only charge phone that it was originally intended to charge and cannot charge other phones	Can charge other phones, but with reduced charging speed	Can only charge phone that it was originally intended to charge and cannot charge other phones	Can charge other phones, but with reduced charging speed	Can only charge phone that it was originally intended to charge and cannot charge other phones	Can charge other phones, but with reduced charging speed
	Improvement	Can charge other phones, but with reduced charging speed	Can charge other phones ensuring the same charging speed	Can charge other phones, but with reduced charging speed	Can charge other phones ensuring the same charging speed	Can charge other phones, but with reduced charging speed	Can charge other phones ensuring the same charging speed
Price premium achieving the same consumer preference share		8%	4%	20%	13%	12%	8%

Source: Ipsos consumer survey (2019), N = 4,906

3.6 The environmental perspective

There are important environmental impacts associated with chargers. The production of each charger (EPS and cable) requires raw materials; their production and transport also generate CO_2 emissions. When chargers are no longer used, they generate electronic waste. The higher the number of chargers produced, used, and eventually discarded, the more significant these impacts are, similarly as they become more complex and heavier. These environmental concerns were considered a serious issue by 72% of the EU citizens who took part in the Public Consultation on mobile phone chargers. Furthermore, respondents overwhelmingly felt that chargers are often not properly recycled or reused, but simply thrown away or left in drawers. In this section we set out the key environmental impacts of the current situation in terms of material use, emissions and waste.

Material composition and usage of chargers

Understanding the material composition of a charger, i.e. which materials are used, in which proportions and from which sources (primary or recycled materials), is crucial to understanding the nature and scale of the environmental impacts of the current situation, as well as those associated with different policy options.

The 2014 RPA study did not investigate the material composition of chargers in detail. It estimated material savings on the basis of an average charger weight of 60g derived from weighing various models. In addition, an assumption was made that around 30% of the content of a charger was from recycled materials. There was no specification of material types.

To account for changes in chargers and improved information since 2014 we have carried out a new review of the available Life Cycle Analysis and other literature and discussed this issue with experts to build up an improved picture of charger composition. Important aspects to note from the review are:

1. There is relatively little information on chargers. Most relevant Life Cycle Analysis (LCA) studies focus on smartphones as a whole, often neglecting to include or disaggregate the charger-related impacts.

2. The difference in composition, weight and impact between different charger types appears to be small. This is especially the case for different cables and connectors (USB micro-B / USB C / Lightning) where there seems to be little tangible difference in the volume and type of materials used.

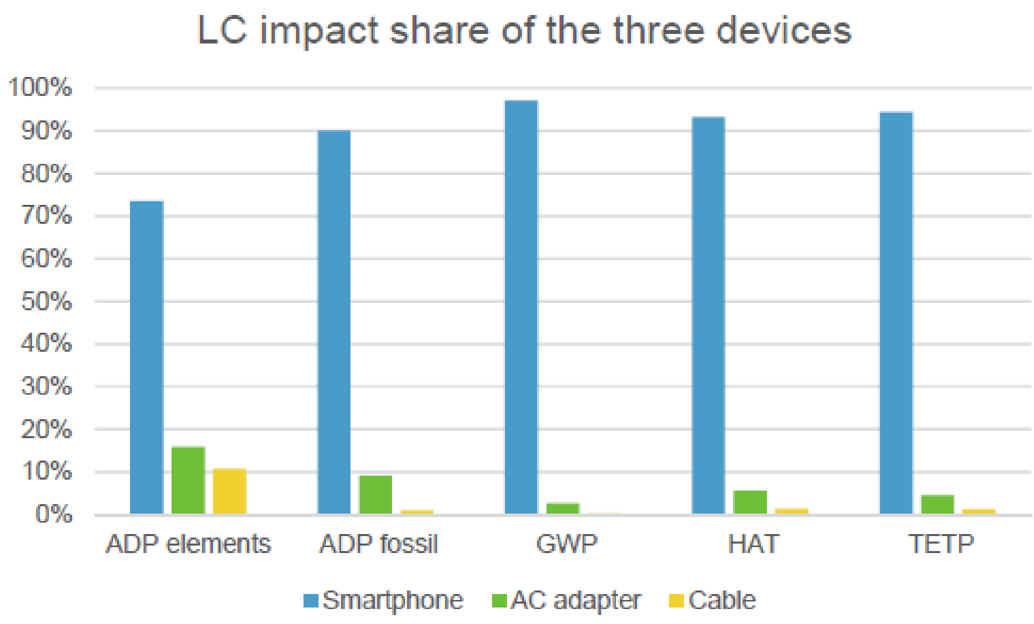
3. The largest part of environmental impacts is tied to the EPS, not the cable – due to the higher weight and value of materials used.

In relation to point 3 above, Life-Cycle Assessments generally conclude that the EPS has a significantly higher environmental impact than the cable, mainly due to its greater weight.[29] The LCA conducted by the SustainablySMART project assessed impacts in terms of Global Warming Potential (GWP), abiotic depletion (ADP) of elements, abiotic depletion of fossil fuels, human toxicity potential (HAT) and terrestrial eco-toxicity potential (TETP). The figure below shows the relative impacts of

[29] SustainablySMART (2019) Regulation of Common Chargers for Smartphones and other Compatible Devices: Screening Life Cycle Assessment. Policy Brief No. 2. Available at: https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-6427186/feedback/F18050_fr?p_id=342389; Ercan, M. (2013), Global Warming Potential of a Smartphone Using Life Cycle Assessment Methodology, Master of Science Thesis, Royal Institute of Technology, Stockholm. Available at: http://kth.diva-portal.org/smash/get/diva2:677729/FULLTEXT01.pdf; Charles River Associates (2015) Harmonising chargers for mobile telephones Impact assessment of options to achieve the harmonisation of chargers for mobile phones

the smartphone, EPS (AC adapter) and cable, as a share of total impacts per category. This demonstrates the relatively low impact of chargers, and within this, the cable compared to the EPS.

Figure 16: Share of environmental impacts for smartphones and chargers, split by component



Source: SustainablySMART (2019) Regulation of Common Chargers for Smartphones and other Compatible Devices: Screening Life Cycle Assessment. Policy

Specific information on the material composition of chargers is not widely available. It is clear that plastics in the casing of both the EPS and cable contribute a large part of the weight of a charger, but also that metals and other materials are also used, for example copper in the cable wires, and other metals in the plug pins and connectors. The most specific information we found was based on a disassembly analysis of a Samsung fast charger conducted by Fraunhofer IZM[30], which detailed the main materials contained in the EPS (charging block) and cable as shown in **Table 11** below.

Table 11: Material composition of a Samsung fast charger

Material	Contained in the EPS (weight in grams)	Contained in the cable (weight in grams)
Plastics	19.74	10.20
Copper	0.47	3.22
Steel	0.75	6.98
Ferrite	6.37	
Aluminium[31]	1.70	
Unspecified[32]	9.06	
Total weight	**38.08**	**20.40**

Source: Adapted from an unpublished disassembly analysis performed by Fraunhofer IZM in the framework of the SustainablySMART project

[30] Provided to the study team by the Horizon 2020 project SustainablySMART

[31] It was assumed that the electrolytic capacitors, which weigh in total 3.4g, are made up of 50% aluminium.

[32] Materials contained in some components of the circuit board and transformer

Based on the SustainablySMART study, other sources and weighing of a selection of other charger types we constructed a material composition profile for each mobile phone charger component type. This specified its composition in terms of the weight of plastics, copper and other materials. These selections were made based on the volume and value of the materials, and also their recyclability. As a result, although there are significant volumes of steel and ferrite also contained within chargers, these are not specifically modelled due to low value (steel and ferrite), low volumes (aluminium) and difficulty in recycling (ferrite). We modelled material composition as follows:

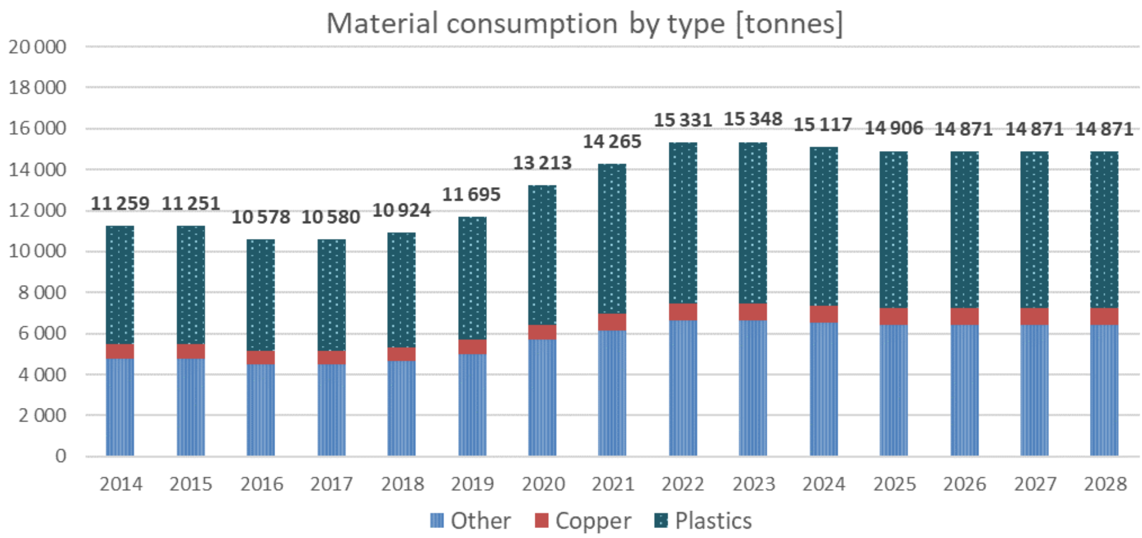
Table 12: Material composition profiles of charger component types

Charger component	Types	Weight [g]	Of which:		
			Plastic [g]	Copper [g]	Other [g]
EPS -USB A	USB A - Standard charger	32.2	16.7	0.4	15.1
EPS -USB A	USB A - Fast charger - USB-PD	67.4	34.9	0.8	31.6
EPS -USB A	USB A - Fast charger - QuickCharge	48.4	25.1	0.6	22.7
EPS - USB C	USB C - Standard charger	35.0	18.1	0.4	16.4
EPS - USB C	USB C - Fast charger - USB-PD	56.3	29.2	0.7	26.4
EPS - USB C	USB C - Fast charger - QuickCharge	52.0	27.0	0.6	24.4
Cables (1m)	USB A - USB Micro B	17.6	8.8	2.8	6.0
Cables (1m)	USB A - USB C	25.0	12.5	3.9	8.6
Cables (1m)	USB A - proprietary	15.8	7.9	2.5	5.4
Cables (1m)	USB C - USB Micro B	21.3	10.7	3.4	7.3
Cables (1m)	USB C - USB C	25.0	12.5	3.9	8.6
Cables (1m)	USB C - proprietary	20.4	10.2	3.2	7.0
Adapter	Adapter USB Micro B - USB C	2.0	1.0	0.0	1.0
Adapter	Adapter Proprietary - USB Micro B	2.0	1.0	0.0	1.0
Adapter	Adapter Proprietary - USB C	2.0	1.0	0.0	1.0
Adapter	Adapter USB A-USB C	2.0	1.0	0.0	1.0

Note: not all materials sub-values will sum exactly to weight due to rounding.
Source: own calculations based on multiple sources including CRA (2015), Ercan et al (2016), Charger Lab, Amazon.

Combining these profiles with the stock model allows for an estimation of the total material use associated with the chargers added to the market each year. The results for our baseline scenario are presented below. This shows an increasing trend in material consumption to 2023, from around 10,900 tonnes in 2018 to 15,350 tonnes in 2022 (+41%). This increase is driven by the trend towards fast charging EPS, these are heavier than 'standard' EPS chargers. Indeed, the average weight of a single charger is modelled to increase from 57g to 81g in this same period. The EPS accounts for around 67% of the materials in 2018, increasing to 70% by 2022. A small decline in all these trends is observed after 2022, as a trend towards slightly lighter EPS, i.e. those with USB C ports rather than USB A, is modelled.

Figure 17: Material consumption of chargers sold each year in the baseline scenario, by material [tonnes], 2014-2028



Source: Stock model

We note that a portion of the materials used to produce a charger may come from recycled sources, such that the actual environmental impact of material consumption may be lower than the values presented above. The RPA study[33] assumed that chargers consisted of 30% recycled content, on average, hence the raw material requirement represented 70% of a charger's weight. However, the percentage might not be representative and appears to refer only to the plastics component.[34] In relation to this point we note that the vast majority of chargers in the EU are manufactured outside of the EU (primarily China) where recycling rules and targets are not as strict as in the EU. In the past there was the chance that some share of the material content of chargers may have been sourced from waste materials treated in the EU and sent to China for recycling. No robust data has been found to verify this type of material flow in this work. Furthermore, policy changes in China announced in 2018 have seriously curtailed its import of waste materials such as plastics, low grade copper scrap and other materials for recycling[35]. As a result, we believe that there is no significant circularity in materials recovered in the EU being recycled for use in new charger production in China. Nonetheless, recycling volumes for the EU remain important, and are addressed in the following sub-sections.

Electronic waste (e-waste) generation

The end-of-life phase of chargers requires their disposal as electronic waste (e-waste) regulated by the Waste on Electrical and Electronic Equipment (WEEE) Directive (2012/19/EU). This Directive has set targets for the collection rate of different e-waste types; data is collected for the IT and telecommunications equipment category, in

[33] RPA (2014)

[34] The assumption is based on a news article announcing the launch of "a line of phone chargers with housings made of at least 30 percent post-consumer plastics". Environmental Leader (2012) AT&T Launches Low-Energy, Recycled Content Chargers, available at: https://www.environmentalleader.com/2012/09/att-launches-low-energy-recycled-content-chargers/

[35] https://www.reuters.com/article/us-china-metals-scrap/china-copper-importers-seek-new-metal-sources-as-scrap-crackdown-bites-idUSKCN1TT07C

which chargers would typically be included. A target for waste collection of 45%[36] in 2016 and 65% (of the average weight of EEE placed on the market in the three preceding years) in 2019 is set. As of 2016, an EU-wide rate of 56% was being achieved[37]. The WEEE Directive also sets targets relating to how this collected waste is treated, stating that from August 2018, 75% should be recovered and by 2019, 55% should be prepared for re-use or recycled. In 2016, the respective rates were 89.1% and 83.3%, demonstrating that these targets have already been achieved. These figures show that in this category of e-waste significant efforts on recycling are being made. However, not all consumers dispose of their old charger as soon as they replace their phone, and not all discarded chargers are properly recycled.

Further examination of data on how and when chargers are disposed found only limited information. Among the relevant data, a study based on a survey of 150 inhabitants of the city of Oulu, Finland in 2013 found that 55% of respondents had two or more unused mobile phones at home[38], demonstrating that chargers are often kept for extended periods when not in use and before being disposed of. Pointing to a potentially long deferment of e-waste following phone purchase.

We investigated different aspects of this issue through the consumer survey, asking respondents a specific question on their mobile phone charger disposal methods. The responses suggested that most chargers are either in use by the original owner or others (30%) or are retained by users (41%). Of the 25% actually disposed, around 19% are recycled and 6% are disposed of (incorrectly) as general waste. Similarly within the consumer survey, questions were asked which distinguished between charger ownership and chargers in use, with average values of 3.2 and 1.8, respectively, indicating around 1.4 chargers per person are on average kept at home unused. These would not be considered e-waste until eventually disposed.

Table 13: Consumer survey response, charger disposal

D3. How do you usually dispose of mobile phone chargers you are no longer using?	**%**
I still use all my old mobile phone chargers	14%
I pass them on to friends or family members	12%
I sell them online	4%
I usually keep them in my house	41%
I recycle them	19%
I throw them into my general-purpose rubbish bin	6%
99. Don’t know	3%

Source: Ipsos consumer survey (2019), N = 5,002

Taking these factors into account we have calculated e-waste volumes on the basis of the charger weight profiles (see **Table 12**) multiplied by estimated disposals from the stock of chargers in a given year after purchase, **Table 5** explains in more detail the assumptions on disposal. The main part of this is that our assumptions reflect a large number of chargers being stored, but eventually being disposed over the course of a 10 year lifecycle.

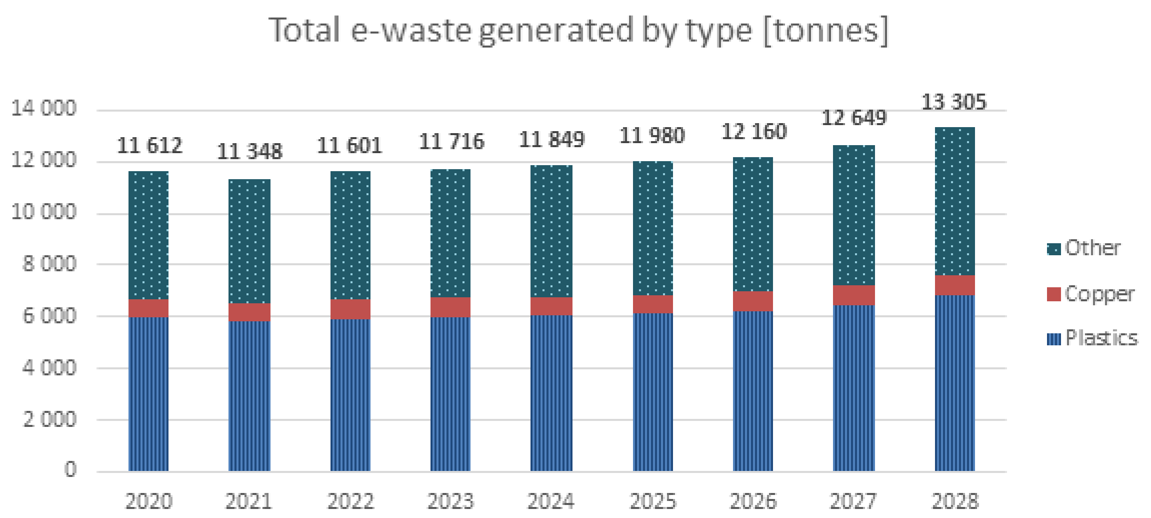
[36] of total weight WEEE collected as a percentage of the average weight of WEEE placed on the market in the three preceding years.

[37] Eurostat (2019) Waste electrical and electronic equipment (WEEE) by waste management operations [env_waselee]

[38] Jenni Ylä-Mella, Riitta L. Keiski, Eva Pongrácz (2013) Electronic waste recovery in Finland: Consumers’ perceptions towards recycling and re-use of mobile phones. *Waste Management* 45, pp.374–384.

The results for e-waste generation in the baseline scenario are presented below and show that between 2020 and 2028 average e-waste generation is around 11,300-13,300 tonnes per year. In the first part of the period there is a slight decline in e-waste generation, reflecting the overall decline in charger (mobile phone) sales from 2008-2018. An increase in e-waste generation from 2021 onwards reflects the modelled stabilisation of sales and increase in average weight of chargers. In terms of overall e-waste volumes in the EU, 12,000 tonnes represents only 0.3% of total WEEE collection in 2016 of 4.5 million tonnes, and 1.8% of the 670,000 tonnes of total IT and telecommunications waste equipment collection.

Figure 18: E-waste generation of chargers disposed each year in the baseline scenario, by material [tonnes], 2020-2028



Note: As the stock model only models charger additions since 2008, e-waste generation does not include all earlier years of disposals until 2020, therefore the years prior to 2020 have been left out of the figure to show only results fully comparable over time.
Source: Stock model

Treatment and recycling of materials

From an environmental perspective volumes of untreated charger waste are one of the main negative impacts and drivers of potential policy action. By untreated waste we refer to chargers that are either incorrectly disposed, e.g. thrown into general waste disposal, or chargers that are collected for treatment but not appropriately treated. The previous section gave some insight into the latter issue, which demonstrated that although collection rates are not high, for waste that is collected for treatment, almost 90% is recovered, and around 83% is re-used or recycled. We focus therefore on the former problem, of incorrect disposal as being the main source of environmental impact. The stock model addresses both the recycled and incorrectly disposed parts of the charger e-waste stream.

Recycling of materials from disposed chargers can mitigate the environmental impact of the materials originally used. However, as noted previously, the recycled materials recovered from chargers in the EU are not expected to be used in new chargers due to restrictions on the import of waste materials for recycling by China, the main charger manufacturing country. Nevertheless collected e-waste materials can still find alternative uses in the EU secondary raw materials markets or in other export destinations. There are three key factors in estimating recycling volumes, (1) the recyclability of the materials found in chargers; (2) the volume of chargers disposed and the method of disposal; (3) the way in which disposed chargers are treated.

Addressing the first point, the LCA study on chargers performed by Fraunhofer IZM[39] assumes that the two main recyclable materials are plastic (Polycarbonates) and copper. Assuming a maximum recovery rate of 84% for plastic and 92% for copper, the authors estimate that 16.59 g of plastic and 0.43 g of copper can potentially be recycled from a charger. However, this is a potential, rather than an actual value. An alternative paper by Horta Arduin et al.[40] estimated that the quantity of potentially recyclable materials in 1kg of mobile chargers amounts to 39%, based on a sample charger (model not specified). The main recyclable material is copper (27%), followed by plastics (polyethylene and PVC, about 5% each). According to the authors, silver, nickel, gold, palladium, and lead can also be recycled, but the recyclable quantities of these materials are very small. The potentially recyclable metals represent only 26% of the total weight of the printed circuit board. The authors note that polycarbonate makes up 42.3% of the charger weight, and at the time of their paper there was no recycling channel in France (home country of the authors) for this type of plastic originating from WEEE.

The second point is addressed by the assumptions in the stock model, which make use of the information from the consumer survey and other sources (see Table 5 for more details). This calculates the number and types of chargers disposed over time and their method of disposal, e.g. to appropriate waste treatment channels for WEEE, or to general waste.

On the third point, the 2014 RPA study[41] estimated a 4% recycling rate of old chargers, assuming the recycling rate of chargers is similar to the recycling rate of mobile phones, as estimated in a survey from Australia[42]. The WEEE statistics referred to at the start of the previous section, indicate that in the EU28 collection and subsequent recycling rates for IT and telecommunications equipment are considerably higher.

Based on continuing improvements in these rates and recycling systems, as well as the consumer survey feedback, we modelled an increase in the collection rate to 75% and incorrect disposal (to general waste) rate of 25% in 2019. These ratios were applied to all materials and modelled to evolve over time, with the collection rate increasing by 1 percentage point per year to 2028, but also having increased to 75% in 2019 at the same rate from a lower level in 2008. The results for the baseline scenario are presented below in Figure 20 and **Error! Reference source not found.**. The first figure shows the volumes of untreated waste, declining from around 2,800 tonnes in 2020 to around 2,100 tonnes by 2028. The main driver of this being the increased proportions of waste estimated to be correctly disposed of (as represented by the 1 percentage point annual increase described above). The second figure shows volumes of charger e-waste disposed of for treatment of between 8,700 – 11,200 tonnes between 2020 and 2028, with similar trends and drivers as described for Figure 18.

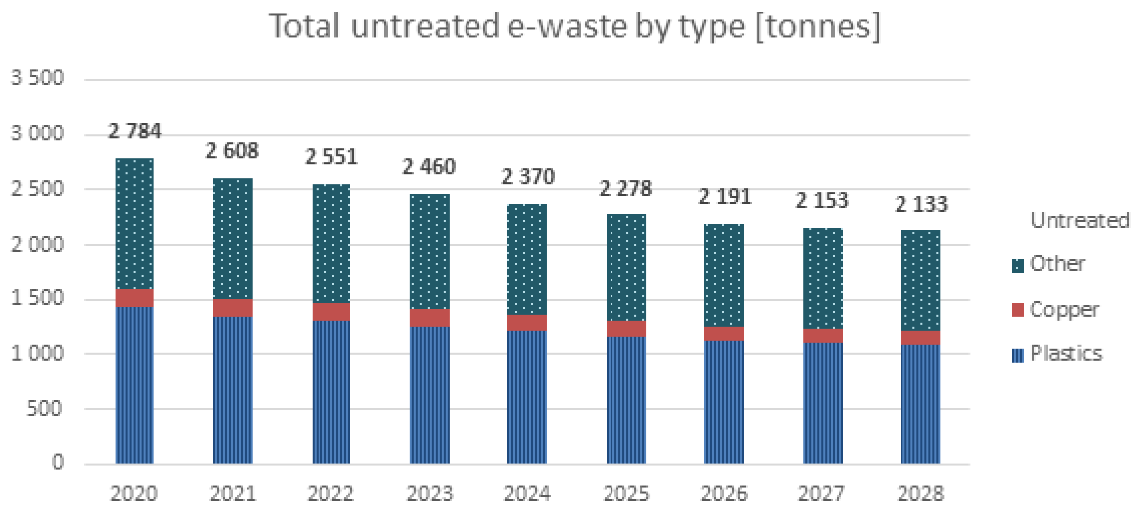
[39] SustainablySMART (2019) Regulation of Common Chargers for Smartphones and other Compatible Devices: Screening Life Cycle Assessment

[40] Rachel Horta Arduin, Carole Charbuillet, Françoise Berthoud, Nicolas Perry (2016) What are the environmental benefits of increasing the WEEE treatment in France? Proceedings of the Electronics Goes Green 2016+ conference, Berlin, September 7 – 9, 2016.

[41] RPA (2014)

[42] GSMA (2006): Mobile Phone Lifecycles, available at http://www.gsma.com/publicpolicy/wp-content/uploads/2012/03/environmobilelifecycles.pdf

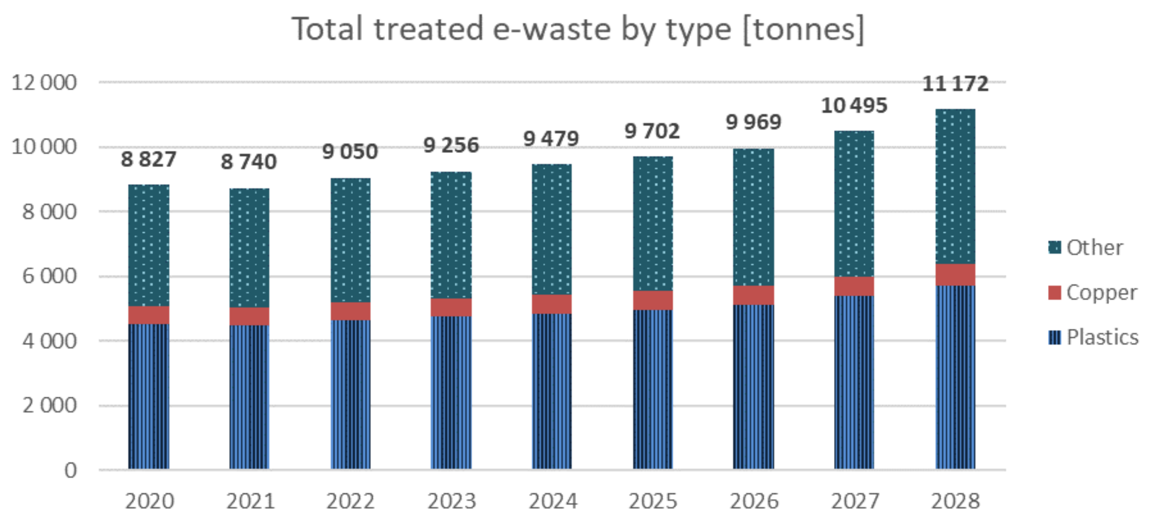
Figure 19: Untreated e-waste each year in the baseline scenario, by material [tonnes], 2020-2028



Note: As the stock model only models charger additions since 2008, e-waste generation does not include all earlier years of disposals until 2020, therefore the years prior to 2020 have been left out of the figure to show only results fully comparable over time.
Source: Stock model

The assumed collection rates provide an idea of the potential maximum of materials recycled. The WEEE data published by Eurostat reports a recycling and re-use rate of 83% in 2016. Applied to the 75% treatment rate in 2019 this could represent an overall recycling rate of around 62%. Yet, we have not taken this additional step in calculating recycling volumes as the statistics and supporting literature do not provide robust detail on how particular materials, and specifically those from chargers are dealt with by recyclers, or how consistent this treatment is across Member States. We do not therefore have high enough confidence to estimate actual volumes of recycled materials. In our opinion, it is likely that recycling rates for copper are the highest for the three material categories we defined, and may approach or even be higher than the level of 83% reported by Eurostat. For plastics and other materials we would expect the actual recycling rates to be considerably lower.

Figure 20: Treated e-waste each year in the baseline scenario, by material [tonnes], 2014-2028



Note: As the stock model only models charger additions since 2008, e-waste generation does not include all earlier years of disposals until 2020, therefore the years prior to 2020 have been left out of the figure to show only results fully comparable over time.
Source: Stock model

CO_2 emissions and other environmental impacts

The other key environmental impact associated with chargers is the greenhouse gas (GHG) emissions of a charger. These are assessed over the full lifecycle, from material extraction, manufacturing, transport, use and disposal. As for other impacts, only a limited number of relevant assessments can be identified for the GHG emissions impact of chargers. The results of those identified in this work are presented below in Table 14, with the sources identified below the table.

Table 14: LCA estimates of embedded CO_2 emissions in chargers

Life-Cycle Phase	Source & charger model	GWP (kg CO_2 eq.)		
		EPS	Cable	Total charger
Raw material acquisition	Ercan (2013) - Sony Xperia T[43]	1.18	0.301	1.48
Manufacturing	Ercan (2013) - Sony Xperia T	0.249	0.0432	0.29
	SustainablySMART (2019) - Samsung fast charger (EP-TA20EWE)[44]	0.898	0.096	0.99
	Charles River Associates (2015) - Apple charger (UK plug)[45]	1.85	0.35	2.20
Transport	Ercan (2013) - Sony Xperia T	0.1729 (transport within China)	0.0692 (transport within China)	0.24 (transport within China)

[43] Weight: 60g EPS, 24g cable
[44] Weight: 38g EPS, 20g cable
[45] Weight: 28.6g EPS, 17.6g cable

Life-Cycle Phase	Source & charger model	GWP (kg CO_2 eq.)		
		EPS	Cable	Total charger
		2.0726 (transport to market, China to Sweden)	0.8290 (transport to market, China to Sweden)	2.90 (transport to market, China to Sweden)
	Charles River Associates (2015) - Apple charger (UK plug)	0.775	0.31	1.085
End of Life (metals recovery)	SustainablySMART (2019) - Samsung fast charger (EP-TA20EWE)	0.011	0.005	0.016

Sources: SustainablySMART (2019) Regulation of Common Chargers for Smartphones and other Compatible Devices: Screening Life Cycle Assessment. Policy Brief No. 2; Ercan, M. (2013), Global Warming Potential of a Smartphone Using Life Cycle Assessment Methodology; Charles River Associates (2015) Harmonising chargers for mobile telephones Impact assessment of options to achieve the harmonisation of chargers for mobile phones

These studies (see sources for Table 14) were analysed and averages calculated for the impact per g for the charger being evaluated in each study as shown in Table 15. These values were used as the basis to calculate the CO_2 emissions impact per charger component (EPS or cable) in proportion to the estimated weight of the relevant component. An example is presented in the table which shows a total impact of 3.34kg CO_2e for this charger. Key observations are that the largest part of the impact is attributable to the EPS which in comparison to the cable is both heavier and has more complex components, each of which contribute to higher emissions.

Table 15: GWP impact assumptions for charger components and example for single charger

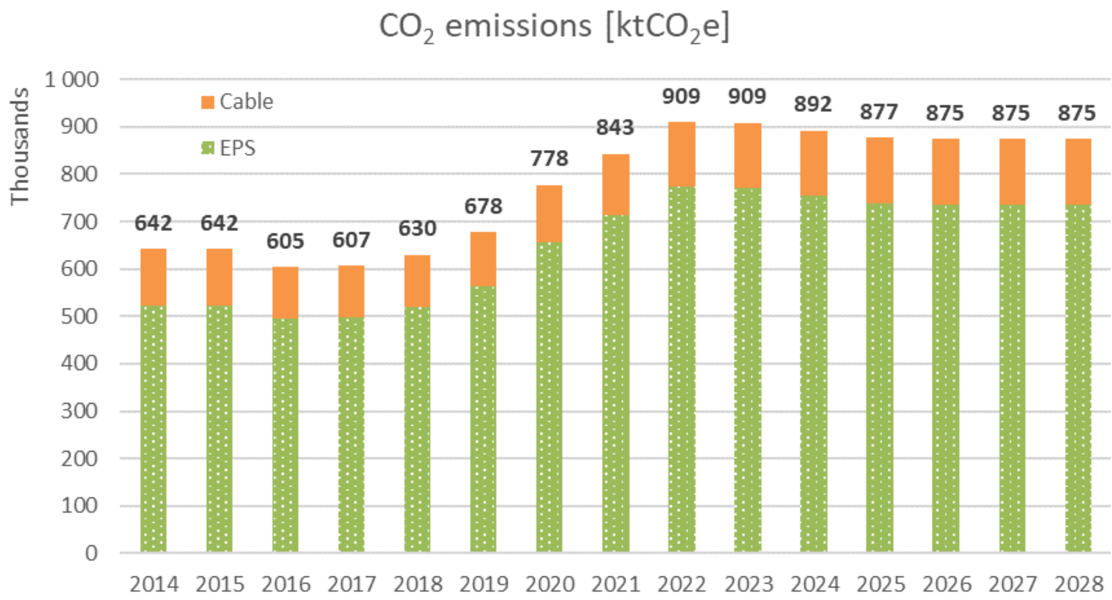
	Average GWP (kgCO_2e) per g weight of component			Average GWP (kg CO_2e) of Samsung fast charger (EPS 38g, cable 20g)		
	EPS	Cable	Total charger	EPS	Cable	Total charger
Raw material acquisition and manufacturing	0.044	0.012	0.056	1.68	0.25	1.93
Transport	0.027	0.018	0.045	1.03	0.36	1.39
End of life	0.0003	0.0002	0.0005	0.01	0.01	0.02
Total	**0.0713**	**0.0302**	**0.1015**	**2.72**	**0.62**	**3.34**

Based on the different charger weight profiles and the annual sales, the stock model is used to calculate total lifecycle CO_2 emissions.[46] The emissions for the baseline scenario are shown below in **Figure 21**, this shows that associated emissions increase from around 630kt CO_2e in 2018 to a peak of around 909kt CO_2e by 2022, before easing to 875kt CO_2e by 2026. The main driver of this being the growth of fast

[46] Noting that all emissions are accounted in the year of purchase, not over a hypothetical life cycle period.

charging EPS, which are assumed to be heavier than current 'standard' EPS. It should be noted that more than half of these emissions are attributed to raw material acquisition and manufacturing and therefore will be accounted in China and other manufacturing countries, mostly outside of the EU.

Figure 21: Life cycle CO_2 emissions for charger additions in the baseline scenario, by component [kt CO_2e], 2014-2028



Source: Stock model

3.7 The perspective of economic operators

During the interviews conducted, industry representatives from across different sectors (industry associations, mobile phone manufacturers, charger manufacturers, and distributors) and standardisation bodies shared their views on the current situation of mobile phone chargers and their interoperability. Overall, interviewees agreed that the MoU was effective at harmonising charging solutions towards USB micro-B and, although they agreed that this transition would have happened regardless, the MoU boosted this move.

When asked about the current situation, interviewees were divided between those who consider that the market is already harmonised and there is not a problem that needs to be addressed (a majority across all groups of stakeholders), and those who thought proprietary solutions should not be allowed in the future (a minority of mobile phone manufacturers). Interviewees' comments on the different components of the charger are briefly summarised below.

External Power Supply

According to most interviewees, EPS are currently harmonised, since EPS that are compliant with relevant standards are backwards and forwards compatible, which means that consumers can charge their phones with their old chargers, and *vice-versa*. There was a general belief amongst those interviewed that manufacturers using proprietary solutions are gradually and naturally transitioning towards standardised solutions as specifications are published and updated. Despite this natural transition, most industry representatives were opposed to mandating for certain standards, such as the IEC 62680 series (although a minority were in favour). Reasons against "forced" harmonisation include:

- It would send the "wrong" signal for manufacturers that complied with IEC 62684, which would not be valid any longer in the EU;
- The difference in cost between EPS using USB PD and "standard EPS" (compliant with IEC 62684)[47];
- Design limitations that such a regulation would impose. Fast charging (via USB PD) produces more heat, which limits battery life. According to some interviewees, industry should be able to design the charger that provides the best trade-off between fast charging and battery life.

Industry representatives were also asked about the possibility of mandating for a more restricted EPS with, for instance, specific voltage and current levels to charge all phones and, potentially, other devices. Industry seemed particularly concerned when considering this option, and raised that it could lead to sub-optimal outcomes, since different devices frequently have different charging profiles.

Connectors on the EPS

Industry representatives were very positive on the impact of the 2009 MoU on the harmonisation of the connector on the EPS end, a situation that has been maintained to date. There are no longer any phones with EPS with captive cables and, until very recently, all EPS had a USB Type-A connector. Most recently, however, some EPS included in the box with high-end phones have a USB Type-C connector. All interviewees (including also non-industry stakeholders) agreed that mandating for the use of USB Type-C only at the EPS end would be detrimental for consumers and the environment, given the current existing infrastructure for USB Type-A. In addition, EPS with USB Type-C connectors have a higher cost that EPS with USB Type-A connectors.[48]

Connectors on the device

The connector on the device is the element of the charger where there is currently most fragmentation. Three main solutions co-exist, which are not interoperable with each other (unless an adaptor is included): USB micro-B, USB Type-C, and Lightning. In addition, whereas for the other elements there was consensus amongst the industry that there is a low degree of fragmentation (i.e. there is no problem that needs to be addressed, and that regulation is not needed to achieve further harmonisation), in the case of the connector on the device, some interviewees considered regulation is the only possible way to achieve harmonisation, although with reservations (e.g. limited scope of devices, inclusion of adaptors for compliance). Most interviewees considered that mandating for USB Type-C would not have major implications for their companies if sufficient transition time is allowed, since they are moving towards USB Type-C anyway. However, one manufacturer claimed that their proprietary connector is better suited to charge their phones, and that using USB Type-C instead would require profound changes in the design of their phones (mainly due to the bigger size of USB Type-C connectors compared to their proprietary solution). This manufacturer argued that in those devices for which USB Type-C is a

[47] For more information on the difference in cost between different charging technologies, see section 5.4
[48] Ibid.

better option than their proprietary solution, they have already made the shift to USB Type-C.

Innovation

One of the main arguments expressed by industry representatives against regulation of any sort (i.e. affecting any of the components described above) is its potential impact on innovation. Obligatory regulation (vs. a voluntary approach), they warn, may decrease investment flows towards R&D projects developing new charging solutions, since mobile manufacturers would not be able to implement any new technology, even if it provided significant advantages over the existing one. In their view, the fact that a new regulation may include provisions to shift towards new (common) charging methods does not solve this issue, since:

1. There is a possibility that new charging technologies are not developed, or are developed at a slower pace, since the incentives for individual companies to invest in developing solutions to provide them with a competitive advantage would be reduced.

2. Even if a new technology was available, it normally takes time to develop the standard. And if this was the case, the company that developed such a technology could not obtain royalties once it is standardised (unless it is done via a Standard Essential Patent).[49]

As an example of how proprietary charging solutions can contribute to the development of new common solutions and standards, a few interviewees commented on the influence of Lightning on the development of USB Type-C. Apple is a member of the USB-IF and contributed to the development of USB Type-C. According to several interviewees (representing members and non-members of the USB-IF), for example the fact that USB Type-C is reversible is in part due to the existence of Lightning, which already incorporated this feature.

Industry representatives provided other examples of innovations happening due to the competitive landscape (lack of regulation towards a standard solution), such as the technological developments in memory cards:

Example: Memory Cards

While it is inherently impossible to predict future innovations that may be impacted by imposing constraints on mobile phone connectors, an instructive example of innovation in the absence of enforced harmonisation is provided by flash memory cards. The format of flash memory cards has developed significantly with the evolution of digital cameras. Designs of memory cards have included: the Sony Memory Stick, CF cards, SD card, mini SD, Micro SD, and others. While it might be seen as inconvenient that, with every new camera purchased, a consumer may have required a new card type, the lack of a prescribed interface led to a competitive race to become the most widely used standard, which in turn led to rapid technological improvements. Adaptors facilitated interoperability between interface generations and, over time, the cards have become smaller as a result of the innovation spurred by competition, using fewer resources and allowing for smaller interfaces on the product side. – *Mobile manufacturer representative*

[49] Standard Essential Patents (SEPs) are patents that are unavoidable for the implementation of a standardised technology. These patents protect innovation that has taken extraordinary effort to achieve. Examples of SEPs in the mobile phone industry are the patents that have been declared essential to the GSM and the 3G, 4G and 5G.

Some of the industry representatives' concerns about the impact that regulation may have on innovation were shared by other stakeholders (some consumer representatives and standardisation bodies) to a certain extent. A consumer representative, for instance, commented on the intrinsic risk that a regulation may preclude the arrival of a better future connector, which could be more convenient and easy to use for people with disabilities. This interviewee suggested as an example the possibility to have magnetic connectors, which is a technology that Apple included in previous versions of their MacBook, but has now been replaced by USB Type-C.

3.8 Illicit markets

There is a shared concern among industry and other stakeholder groups who believe that a significant and growing share of the stand-alone mobile phone chargers that are being sold (primarily online) is counterfeit. While this is difficult to substantiate with objectively verifiable data, comments and discussions about problems with non-genuine chargers (and/or advice on how to identify genuine ones) abound in online fora. The often very significant price differences between ostensibly identical branded chargers on online retail portals, compared with major phone manufacturers' own online shops, raise further doubts as to whether the former are all genuine. According to one report, Apple found in 2016 that 90% of Apple chargers and cables labelled as genuine on Amazon.com were counterfeit.[50]

In the absence of reliable data on the illicit market for counterfeit chargers, statistics compiled by the European Commission on the enforcement of intellectual property rights (IPR) by EU customs authorities may at least provide a sense of the likely scale of the problem. According to the latest report,[51] of the nearly 90,000 procedures that were associated with the over 69,000 cases of detentions of counterfeit goods at the EU borders in 2018, 4,547 (or 5.1%) were of "parts and technical accessories for mobile phones" (product category 6b). A total of nearly 1.1 million products in this category were seized, with a domestic retail value (based on the retail price at which the goods would have been sold had they been genuine) of over €39 million (the sixth highest among the 36 product categories recorded). The countries of provenance of almost 97% of these products were Hong Kong and China. Since 2012, the number of procedures concerning parts and technical accessories for mobile phones in 2017 has oscillated between around 2,500 and 5,000 (with a peak in 2015). Unfortunately, on request, the Commission was unable to provide more detailed data (or estimates) of the proportion of these figures that relate specifically to chargers (as opposed to other mobile phone parts or accessories). It is also important to emphasise that the figures only relate to counterfeit goods that were detained at the EU border, not the (potentially much higher) numbers that went undetected.

The existence of a significant market for counterfeit chargers raises serious concerns, in terms of the direct (foregone sales) and/or indirect (e.g. due to a negative effect on their brand reputation) economic losses to the holders of the intellectual property rights (usually the large mobile phone manufacturers themselves), as well as in terms of product safety for users (see below). Industry representatives in particular tended to argue that the situation could potentially be exacerbated further with the introduction of a single common charger, in so far as this could increase the demand

[50] URL: https://www.telegraph.co.uk/technology/2016/10/20/apple-finds-90-of-its-chargers-and-cables-on-amazon-are-fake/

[51] European Commission (2019): Report on the EU customs enforcement of intellectual property rights: Results at the EU border, 2018

for (frequently counterfeit) stand-alone chargers, as well as simplify the production chain for chargers, and therefore facilitate the production of counterfeit chargers.

3.9 Product safety

Product safety is an important issue for chargers. Serious safety issues for chargers most often relate to electric shock, electrocution and fire risks from poorly designed and manufactured chargers. These problems primarily affect the EPS. The assessment here is based on desk review and interviews with national authorities and a safety organisation.

The issue primarily affects standalone charger sales, as chargers supplied with phones are tested by manufacturers and well matched to their devices. Whilst there are a number of suppliers of good quality standalone chargers (such as Belkin, Anker, etc.), there are also many more products where the quality and compliance with safety standards is not guaranteed. These products can be from minor, less well-known brands, or unbranded. Counterfeit products are also an issue, with imitations of (especially) Apple but also other major brands not being manufactured to the same standards. The 2014 assessment flagged safety as a particular issue for standalone chargers, noting 'that as much as 30-60% of the standalone charger market may not comply with applicable technical standards, some of which relate to safety'. This being in large part attributable to chargers produced by non-OEM firms, which were often, but not always, counterfeits. A contributory factor is also the growth in online purchases sent direct to consumers which are more difficult to regulate and where counterfeit products are more common.

Among the EU citizens that participated in the Public Consultation on mobile phone chargers, 31% were concerned by the consequences of the current situation in terms of safety. The majority of these agreed that chargers which are unbranded or not of the same brand, and/or not designed for the specific mobile phone, are potentially unsafe, and also that there are many counterfeit chargers which are potentially unsafe. Corroborating this level of concern were similar results in the consumer survey, where 31% of respondents reported that a charger had become unsafe to use within the last 24 months, pointing to a not insignificant problem with product safety.

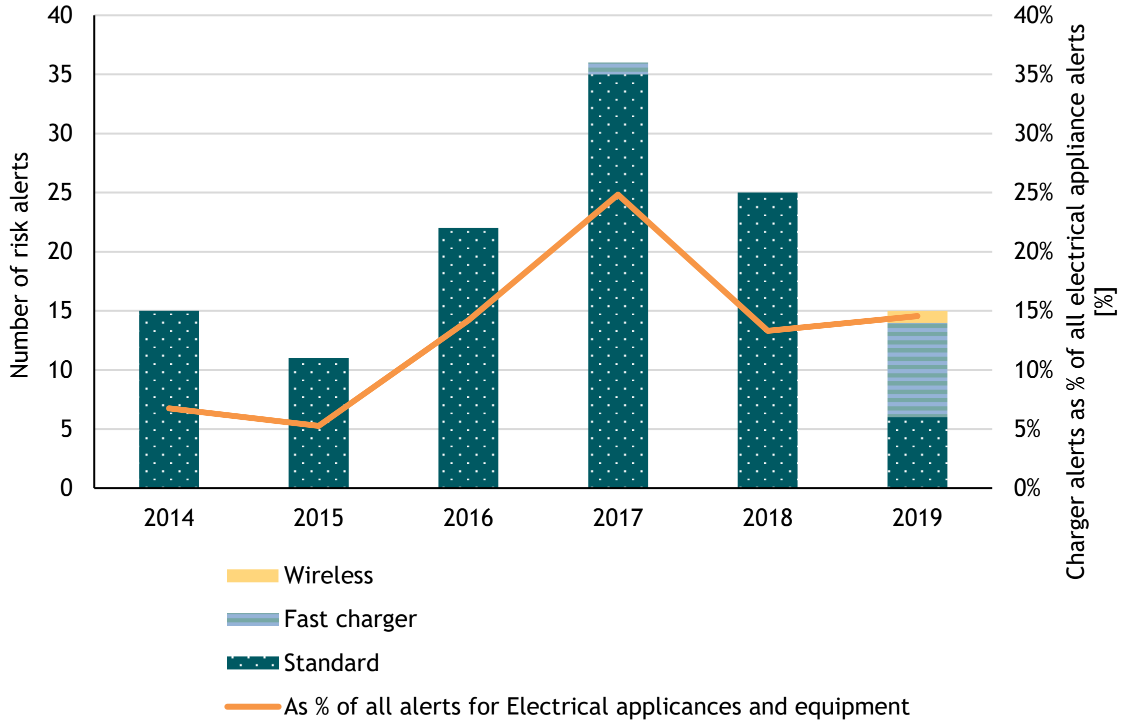
RAPEX

The results of an analysis of the number of risk alerts (serious product risks or other risks) for mobile phone chargers between 2014 and part of 2019 from RAPEX[52], indicates that there is an increasing trend in the detection of phone chargers that pose risks to consumers (see Figure 22 below). Most of the alerts were submitted for standard mobile phone chargers, although in recent years risk alerts for fast chargers and wireless chargers have started to appear as well. The numbers for chargers represent between 5-25% of the total RAPEX alerts in the category Electrical appliances and equipment, where an increasing trend is becoming evident, highlighting that chargers are becoming a more significant problem in the area of electrical equipment, at least in terms of RAPEX alerts. These numbers compare to values recorded in the 2014 study for 2008-2013 of 67 in total, ranging from 7 to 16

[52] RAPEX is the EU rapid alert system for dangerous non-food products. The analysis included alerts for products with serious alerts and risks of fire, burns or electric shock, in the category "Electrical appliances and equipment" up to the end of May, 2019. Almost all represented non-compliance under the Low Voltage Directive. Further filtering was carried out to include only alerts specific to mobile phone chargers. The following items were out of scope: laptop chargers, chargers specific for other devices (game consoles, LED lights, e-cigarettes, etc.), socket adaptors for multiple regions, car power adaptors for devices in general, USB stand-alone cables and power banks.

per year. When compared to the values from 2014 onwards this points to an increasing trend[53]. It should be noted that there are various limitations to the interpretation of RAPEX data, as can be seen, it highlights only a handful of alerts each year (relative to the much higher number of chargers or devices as a whole). It should also be noted that the resources available to national market surveillance authorities and their usage (or not) of the RAPEX system is also uneven across MS.

Figure 22: Number of risk alerts in the EU28 for mobile chargers from 2014 to 2019 by type of charger



Source: Own elaboration based on RAPEX
Note: It should be noted that these alerts only refer to those that are detected by the national authorities and economic operators and that 2019 only includes alerts submitted in the first 5 months of 2019, therefore the number of alerts at the end of 2019 could surpass those of 2018.

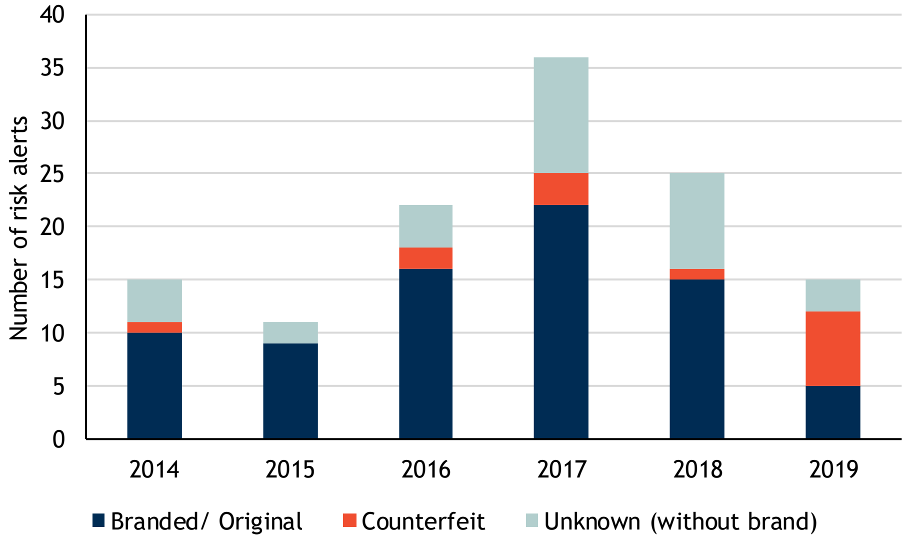
More than 60% of the products with risk alerts analysed were original brands of chargers for phones or compatible devices (e.g. tablets) – see Figure 23. Almost a third of the alerts were chargers without a brand, while 11% of the alerts were counterfeit chargers pretending to pass for chargers of popular brands like Apple and Samsung. Counterfeit products pose an important safety threat, and are an issue that is increasing in general. The latest reports on this issue highlight mobile phone chargers and accessories that are bought online and shipped direct to consumers[54]. Other independent reports also highlight the safety risks of counterfeit products, with a report by Electrical Safety First in the UK finding only 1 of 64 counterfeit Apple chargers passed all technical and safety tests[55].

[53] There may be some small differences in methodology applied between the 2014 study and this study.

[54] https://euipo.europa.eu/tunnel-web/secure/webdav/guest/document_library/observatory/documents/reports/2019_IP_Crime_Threat_Assessment_Report/2019_IP_Crime_Threat_Assessment_Report.pdf

[55] https://www.electricalsafetyfirst.org.uk/media/1119/counterfeit-and-imitation-apple-chargers.pdf

Figure 23: Number of risk alerts in the EU28 for mobile chargers from 2014 to 2019 by brand



Source: Own elaboration based on RAPEX

From the RAPEX data, almost all of the defects that triggered the risk alerts failed to comply with safety requirements of the Low Voltage Directive[56], due to one or more of the following defects:

- Insufficient clearance or creepage distance between the primary and secondary parts of the transformer and the circuits, which could lead to the user receiving an electric shock;
- Lack of additional fixing of the soldered connections of the primary circuits. If a wire disconnects, the creepage distances and clearances of the reinforced insulation may be reduced;
- Inadequate electrical insulation and/or housing that is not sufficiently resistant to heat or breaking, as a result live parts could become accessible to the user and cause an electric shock, burns and a fire;
- Poor product design, that does not withstand foreseeable electric current overloads, leading to the overheating of components with the risk fire.

ICSMS

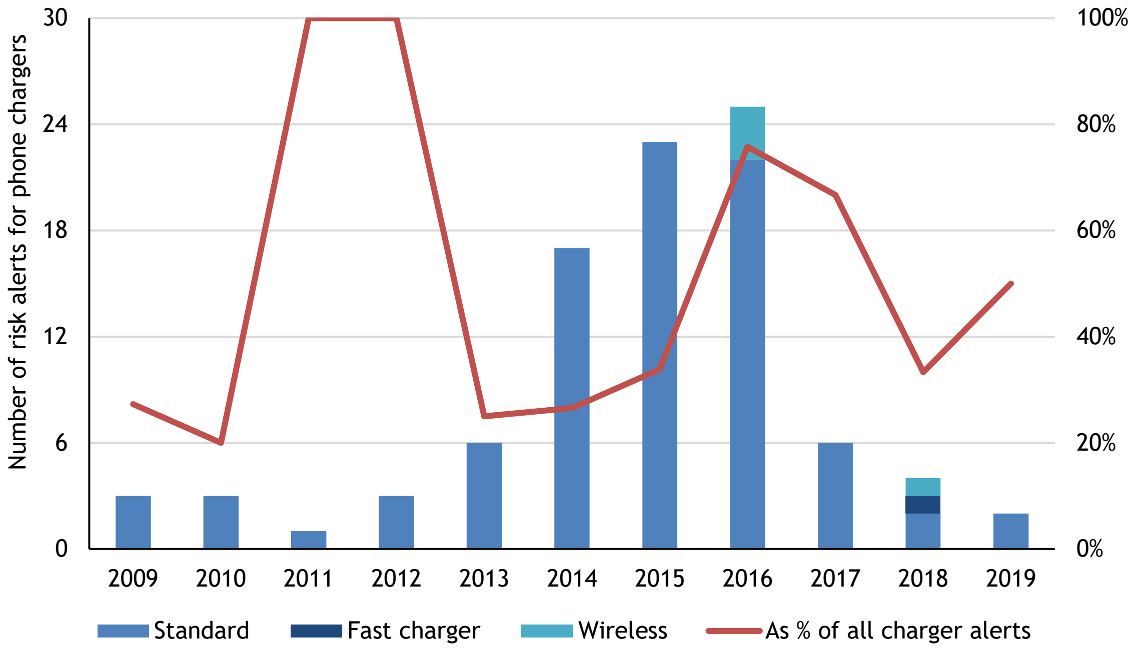
The Information and Communication System on Market Surveillance (ICSMS) is another database used to exchange and store information on inspection findings. In the case of the ICSMS, market surveillance bodies make use of the platform on a voluntary basis. A search for "charger" products between 2009 to 2019[57] in the platform resulted in 244 product safety risk alerts; on average over this period, 38% of these referred specifically to mobile phone chargers, while the rest belong to other

[56] Only one case was found where the product did not have the risk of electric shock or causing a fire. The defect of the product was instead the presence of restricted hazardous substances (ROHS 2), therefore it was non-compliant with the Electronic Waste Directive.

[57] The analysis included alerts for products that included they key word "charger" up to the end of July, 2019.

type of chargers not specific to mobile phones (see Figure 24 below).[58] Regarding mobile phone chargers, the trend in alerts increased up to 2016, after which a significant decline is observed for 2017 and 2018[59]. This trend is somewhat, but not fully, consistent with the alerts reported in RAPEX. Almost all alerts are for standard phone chargers, although in 2018 there was one alert for a wireless charger and one for a fast charger (USB-Type C). It is not clear why the reporting trend is as shown, yet the numbers are also so small that one-off variations can be high.

Figure 24: Number of risk alerts in the EU28 for charger products (2009-2019)



Source: Own elaboration based on the ICSMS platform

Overall, the RAPEX and ICSMS data, supported by feedback from authorities, suggests that there are problems with charger products and that these are increasing. At the same time, data in 2017-2018 does not strictly keep to this trend. It is difficult to draw strong conclusions on these trends and given the weaknesses and gaps in Market Surveillance across the EU and due to other key variables changing over time, such as the available resources and focus on these products by the relevant authorities.

[58] Other / out of scope charger products include laptop chargers, chargers specific for other devices (game consoles, LED lights, e-cigarettes, etc.), socket adaptors for multiple regions, car power adaptors for devices in general, USB stand-alone cables and power banks.

[59] It should be noted that there are considerable differences between the number of records from the 2014 study and this study for the years 2010-2013. The number of overall risk alerts resulting from a search with the same key word (charger) is on some cases higher (for years 2010, and 2013) or considerably lower (for years 2011 and 2012 only 1 and 2 alerts were found, respectively), even though no further filtering was applied in this study. This could be explained by the addition or removal of records in the ICSMS platform after the analysis of the 2014 study was carried out.

3.10 Problem definition

This section summarises the key facets of the current situation as regards mobile phone chargers (as discussed at length in the previous sections) and, based on this, identifies the main problems the initiative being considered is intended to address.

The 2009 MoU brokered by the European Commission helped to facilitate a profound change in the market for mobile phone chargers. The ensuing years saw a significant **reduction in the fragmentation** of charging solutions, the widespread adoption of the "common EPS" in accordance with the international standards developed based on the mandate from the Commission, and convergence of around three quarters of the market to USB micro-B connectors. However, the remainder of the market (essentially corresponding with Apple's iPhones) continued to rely on proprietary connectors (allowed under the terms of the MoU as long as adaptors were available on the market). Also, the reduced fragmentation did not lead to decoupling (i.e. the sale of phones without chargers) except on very small scale, meaning there was no significant reduction of electronic waste.

The years since the definitive expiry of the MoU in 2014 have seen profound **technological changes** as well as significant shifts on the market for mobile phones (and to some extent, for other portable electronic devices with similar charging profiles, which includes tablets, e-readers, cameras and wearables, but not laptops). Some new / emerging technologies appear to be on a pathway to becoming dominant in the next few years, in particular the gradual replacement of USB micro-B by the more advanced USB Type-C connectors (which were already used in nearly three out of ten phones sold in the EU in 2018), and the apparent trend towards fast charging solutions based on (or compatible with) USB Power Delivery (PD). Another technological innovation, wireless charging, is still very incipient, and the market shows no clear signs of converging towards a specific technology yet. Attempts to reach a new voluntary agreement to address the remaining fragmentation of the charging solutions for mobile phones, taking into account the current state of technology, have so far failed to reach a conclusion that the European Commission and many stakeholders would consider satisfactory.

Thus, in summary, **the current situation can be characterised as follows**:

- Absence of any binding (voluntary or regulatory) requirements as regards the interoperability of chargers for either mobile phones or other portable electronic devices.

- A high but not universal degree of interoperability of different charging solutions, due to the fact that cables are almost always detachable from the EPS, and that large parts of the market have adopted technologies (including connectors) based on USB specifications and standards.

- Potentially significant variations in charging performance between brands and devices, due to the wide range of fast charging solutions on the market, meaning that, even if the likelihood is high that any given modern EPS can be used to charge nearly all mobile phones that are currently on the market, it may not do so at the same speed.

- A market in constant evolution, with USB Type-C connectors expected to gradually replace legacy USB connectors at the phone end (within the next few years) as well as the EPS end (more slowly), and innovation in fast and wireless charging technology likely to continue at a rapid pace.

The available evidence points to **two main problems** that arise from this situation:

- **Consumer inconvenience**: According to our survey of a broadly representative panel of consumers in ten EU Member States, most mobile phone users (84% of all respondents) have experienced one or more of a series of problems related to their phone chargers in the last two years. Commonly cited problems (each experienced by between one third and half of respondents) were the inability to charge certain devices (as fast) with certain chargers; having too many chargers taking up space in the home and/or workplace; situations where they needed to charge their phone, but the available chargers were incompatible with it; and confusion about which charger works with what device. While the majority of those who reported having experienced each of these problems did not feel they were particularly serious, a minority of around 15% to 20% of all survey respondents reported one or more of these problems had caused them significant issues.

- **Negative environmental effects**: The production of each charger requires raw materials; their production and transport also generates CO_2 emissions. When chargers are no longer used, they generate electronic waste. The higher the number of chargers produced, used, and eventually discarded – and the more complex and heavier they are – the more significant these impacts. Based on our stock model, we estimate an increasing trend in material consumption, from around 11,000 tonnes in 2018 to 15,350 tonnes in 2024; an average e-waste generation of around 11,000 tonnes per year (a share of 75% and more which is collected for treatment and potential recycling); and associated life cycle emissions increasing from around 600 in 2018 to 900 kt CO_2e per year by 2023, driven primarily by the growth of fast charging (and therefore heavier) EPS.

The main objective of the initiative to create a common charger for mobile phones (and potentially also other portable electronic devices) is to address these problems, while avoiding **unintended negative effects**, in particular the following:

- **Innovation**: The industry (mobile phone manufacturers and other digital industry sectors) are concerned that mandating for a certain type of phone charger would constrain future innovation in the field of charging technology and potentially also other aspects of phones / devices, as it would risk "locking" the industry into a certain technology for longer than would be ideal from the perspective of both economic operators and consumers, and also reduce the incentives for companies to invest in the research and development of new technologies, as the opportunities to use these to gain a competitive advantage would be limited.

- **Illicit markets and product safety**: There appears to be a substantial market for counterfeit chargers, which raises concerns in terms of the direct and/or indirect economic losses to the holders of the intellectual property rights (usually the large mobile phone manufacturers themselves), as well as in terms of product safety for users (as substandard chargers – which do not necessarily have to be counterfeit – imply higher electric shock, electrocution and fire risks). These issues are almost always associated with stand-alone chargers (which are very difficult to control effectively, especially if sold online). It will therefore need to be considered carefully if and how the initiative would affect the market for stand-alone chargers, since an increase in demand could potentially exacerbate the risks.

4. POLICY OPTIONS

This chapter presents the policy options for the potential new initiative on common chargers aimed at addressing the problems identified previously (see section 3.10). It defines the baseline scenario, briefly discusses the various technical and legal elements that were considered and, following from this, provides the short-list of options that are assessed in-depth in the ensuing chapters.

4.1 The baseline

This study treats the new MoU proposed by the industry in 2018 (but not endorsed by the Commission) as the baseline (i.e. the "no policy change" scenario). As outlined previously (see section 3.1), the MoU's signatories committed that, beginning no later than three years from the date of signing, any new smartphone models they introduce to the EU market will be chargeable through a USB Type-C connector or cable assembly. Three types of cable assemblies are considered compliant: (1) those that are terminated on both ends with a USB Type-C plug; (2) those that are terminated on one end with a USB Type-C plug and have a vendor-specific (i.e. proprietary) connect means (hardwired/captive or custom detachable) on the opposite end; and (3) those that sources power to a USB Type-C connector from a USB Type-A connector. For the sake of clarity, the table below summarises the connector combinations that are likely to follow from this in practice (taking into account that, based on the information at our disposal, it seems extremely unlikely that any manufacturer would introduce a proprietary solution at the EPS end in the foreseeable future).

Table 16: Types of connectors envisaged under the 2018 MoU

	Device end	EPS end
Combination 1	USB Type-C	USB Type-C
Combination 2	Proprietary	USB Type-C
Combination 3	USB Type-C	USB Type-A

Furthermore, as part of the baseline, we assume that adaptors from proprietary to USB Type-C connectors will continue to be available for purchase. Unlike its predecessor,[60] the 2018 MoU does not contain a specific commitment in this regard; however, such adaptors are currently widely available on the market, and there is no reason to believe this would no longer be the case in the foreseeable future.

Our main assumptions regarding the evolution of the stock of mobile phone chargers in use, including the split between the different main types of chargers, are shown in section 3.3 above. Most importantly, based on existing market trends and input from key stakeholders, we assume the market shares of key charging solutions for mobile phones will evolve as follows:

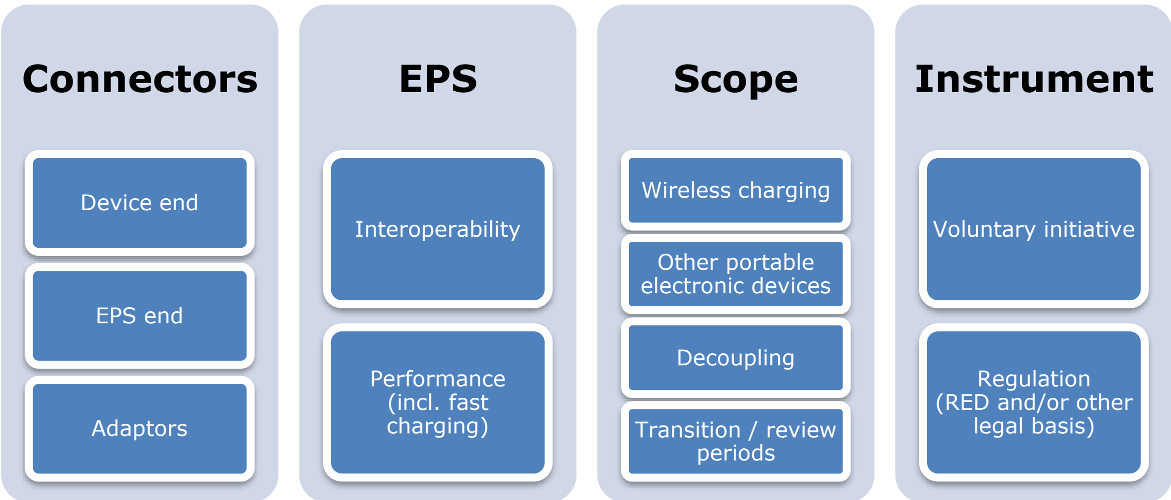
[60] The 2009 MoU stipulated that, "if a manufacturer makes available an Adaptor from the Micro-USB connector of a Common EPS to a specific non-Micro-USB socket in the Mobile Phone, it shall constitute compliance" with the MoU. It defined an "Adaptor" as a device with a Micro-USB receptacle/plug connecting to a specific non Micro-USB connector. It clarified that an Adaptor can also be a cable.

- Connectors at the device end: USB micro-B will gradually be phased out, and will have been replaced by USB Type-C in all new phones sold by 2022. The market share of proprietary connectors will remain constant at 2018 levels.
- Connectors at the EPS end: USB Type-A connectors will gradually be phased out, and will have been replaced by USB Type-C in all new phones sold by 2025 (and will therefore account for 100% of the market).
- EPS: the market share of fast charging EPS will continue to increase, reaching 90% of all in-the-box sales by 2023. The remaining 10% of EPS (corresponding with around half of the market for lower-end phones) will continue to be non-fast charging.

4.2 Elements considered

When considering the idea of a "common" or "harmonised" charger for mobile phones and potentially other portable electronic devices, it is important to be as clear as possible about what is meant by this. As noted previously, charging solutions usually consist of several elements (in particular, a charging block or external power supply (EPS), and a cable assembly to connect the EPS to the device). Although the connectors on the device end of the cable tend to be the first issue that comes to mind when discussing a possible harmonisation initiative (and constitute the focus of the 2018 MoU), the other elements also merit consideration. The question of the scope of the possible initiative is also critically important to address, as is the policy instrument (voluntary or regulatory initiative). Below, we discuss each of the main elements in turn, considering the extent to which the current situation leads to problems and the feasibility of potential solutions, in order to define specific policy options where appropriate. Where this is not the case, we have discarded the element in question from the in-depth assessment, and outline our reasoning behind this.

Figure 25: Schematic overview of elements considered



<u>Connectors on the device end</u>

The current trend on the mobile phone market regarding the connectors on the device end is clear (see section 3.3): the USB micro-B connectors that formed the basis of the 2009 MoU, and were used in around 80% of mobile phones in 2016, are gradually being replaced with the newer USB C connectors. The market share of proprietary connectors (namely Apple's Lightning connectors) continues to be around 20%. In order to achieve further harmonisation of this element, the main option is a (mandatory or voluntary) commitment to USB C as the common solution. A further consideration is the possibility to allow those manufacturers who wish to continue to use proprietary solutions to make available adaptors.

The **policy options we will take forward for in-depth analysis** are:

- **USB Type-C as the only connector at the device end**, with no adaptors allowed

- **Compulsory adaptors in the box**: Manufacturers who wish to continue to use proprietary connectors (receptacles) in their mobile phones are obliged to include an adaptor in the box. There are two technical variations (sub-options) of this:

    - Manufacturers could be obliged to include a cable with a USB Type-C connector. Those who wish to continue to use proprietary (e.g. Lightning) receptacles in their phones would be obliged to provide an adaptor from USB Type-C to their proprietary receptacle in the box.

    - Manufacturers could be allowed to continue to provide cables with either a USB Type-C or a proprietary connector. Manufacturers that choose to provide a cable with a proprietary connector would be obliged to provide an adaptor that enables its use with a USB Type-C receptacle.

Connectors on the EPS end

It is worth considering whether there is a need for / added value in seeking to further harmonise the connectors on the EPS end, in order to ensure that cables are compatible with any EPS. The situation in this respect has evolved considerably since the 2009 MoU, when most charging solutions included captive cables. Today, all mobile phone chargers are sold with detachable cables, the vast majority with a USB Type-A connector on the EPS side. This is expected to gradually shift towards USB Type-C, but this process is much slower than at the device end, inter alia due to the existence of a large amount of USB Type-A sockets / infrastructure, not only in EPS but also in laptops, buildings, cars, public transport etc.

In light of this, we conclude there is no strong case for further harmonisation at the present time regarding the connectors on the EPS end. The level of harmonisation is already very high: all cables are detachable, and there are no proprietary solutions on the market, which ensures the interoperability of the cables with a wide range of EPS (in principle at least; for considerations regarding the EPS itself see below). It would be possible to define USB Type-C as the only solution at the EPS end. However, since the transition to this is under way already (albeit slowly), it seems very likely that the benefits of attempting to accelerate this transition "artificially" would be marginal, and would be outweighed by the costs, as a fast transition would risk making a significant amount of existing EPS, other devices (such as laptops, which can be connected to phones not only for the purpose of charging but also, and arguably more importantly, for data transfer) and charging infrastructure obsolete, with potential negative consequences and costs in terms of both consumers and e-waste.

Therefore, **we will not include this element among the options to be assessed further**. It may be worth considering whether any new initiative should seek to cement the status quo (i.e. detachable cables with either a USB Type-A or a USB Type-C connector at the EPS end), and thereby rule out any potential future fragmentation (though this appears very unlikely at present). However, in view of the available evidence, it appears far preferable to allow the transition from one common solution (USB Type-A) to the next common solution (USB Type-C) to proceed naturally, keeping pace with market developments and the evolution of consumer preferences.

External power supply

As noted previously (see section 3.6), the heavier part of mobile phone chargers, and therefore the one that accounts for most of the environmental impact, is not the cable but the EPS. As part of the 2009 MoU, the EPS was harmonised in accordance with standard IEC 62684 (first published in 2011, updated in 2018), which specifies the interoperability of common EPS for use with data-enabled mobile telephones. It is based on legacy USB technologies (in particular USB micro-B and the corresponding USB charging standards and specifications). It does not cover charging interfaces that implement IEC 62680-1-3 (which defines the USB Type-C receptacles, plug and cables), IEC 62680-1-2 (which defines the USB Power Delivery system) and IEC 63002 (which defines interoperability guidelines[61] for EPS used with portable computing devices that implement the former, ensuring the EPS and device can "communicate" with each other so that the EPS flexibly provides exactly the power the device requires).

Therefore, it is worth considering whether the potential new initiative should address the **interoperability**[62] of the EPS, in order to ensure these are able to charge the widest possible range of mobile phones (and potentially other electronic devices). This could be achieved by laying down interoperability as an essential requirement, which would be concretised through technical specifications provided in formal standards. The development of a new standard for the EPS appears unnecessary, since today (unlike in 2009) relevant international standards already exist (see above). Based on the information at our disposal, most manufacturers voluntarily choose for their mobile phones and corresponding chargers to comply with the standards listed above, as it is typically in their own interest to ensure interoperability. Nonetheless, an explicit and enforceable commitment to these standards could potentially help guarantee their consistent application, and ensure any fast charging solutions that are used / developed are compatible with USB Type-C and/or USB PD.

In this context, another aspect to consider is the charging **performance** (i.e. speed). Fast charging is closely linked to the power provided to the device by the EPS. The power (expressed in watts) is a function of the current (expressed in ampere) and the voltage (expressed in volts). Whereas the most basic USB specification that was predominant at the time of the 2009 MoU only sent between 0.5 and 1 ampere (A) of current using 5 volts (V) for just 2.5 to 5 watts (W), modern fast charging technologies boost these figures, typically to provide 15W or more of power. Although fast charging technologies vary somewhat (see section 3.2), they all share a common theme: more power. In order to ensure EPS are not only interoperable with all phones, but are also guaranteed to provide the performance consumers increasingly come to

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[61] It should be noted that IEC 63002 was adopted as a *guidelines*, rather than a standard as such, which means it is currently difficult to certify and/or enforce. This was reportedly due to the fact that at the time of its finalisation (2013-14), the first generation of USB PD and USB Type-C specifications had only just been developed, and market adoption was still limited. Now that these specifications have been updated numerous times and adopted widely on the market, IEC 63002 is currently being revised, in order to update it in view of the latest USB PD standard and safety standard, and incorporate more requirements to support interoperability.

[62] For clarification, the term "interoperability" refers to the ability of a device or system to work with or use the parts or equipment of another device or system. Thus, an EPS is considered "interoperable" with a particular device if it is capable of charging its battery at a reasonable (though not necessarily the maximum possible) speed and without a risk of causing any damage or other significant negative effects. This requires not only compatible connectors and cables, but also the provision of the "right" amount of power. USB Power Delivery achieves this via a process called "power delivery negotiation", which matches the power delivered by the EPS to the requirement of the device (up to a maximum of 20V, 5A and 100W).

expect, a future common EPS could therefore include minimum specifications in terms of power (as another essential requirement).[63]

Therefore, the **policy options we propose to take forward for in-depth analysis** are:

- **Guaranteed interoperability of EPS**: This would entail a commitment (via a voluntary agreement or an essential requirement enshrined in regulation) to ensuring all EPS for mobile phones are interoperable (i.e. capable of charging any mobile phone). This would need to be concretised via reference to compliance with the relevant USB standards, in particular IEC 63002 (which provides interoperability guidelines) and/or, where still required, relevant standards in series IEC 62680 or IEC 62684.[64] Importantly, this option would not prescribe a specific type of receptacle on the EPS, but allow for the continued use of either USB Type-A or USB Type-C (for the reasons outlined above, see section on Connectors on the EPS end). In other words, the interoperable of all EPS with all mobile phones would be guaranteed, provided a cable with the "right" connectors is used.

- **Interoperability plus minimum power requirements for EPS**: To facilitate adequate charging performance, all EPS for mobile phones would have to guarantee the provision of at least 15W of power (in line with most current fast charging technologies). To also ensure full interoperability, all EPS would have to be capable of "flexible power delivery" in accordance with common standards / specifications (which in practice would be concretised via reference to the USB PD standard IEC 62680-1-2 and IEC 63002).

Wireless charging

The emergence of wireless (inductive) charging solutions raises the question of whether such solutions should also be included within the scope of a possible harmonisation initiative. In principle, such an initiative could seek to define common standards and/or specifications that ensure all wireless chargers are interoperable with all mobile phones that are wireless-charging enabled, independently of the manufacturer.

However, as discussed previously (see section 3.2), wireless charging is a very incipient technology. At present, its energy efficiency and charging speed cannot match those of wired solutions, and there are no indications that wireless charging is likely to become the dominant solution, or even make wired charging obsolete, in the foreseeable future.[65] Three main technologies for wireless charging currently co-exist; these are not mutually exclusive, and it is not yet clear which of these (if any) is

[63] It is worth noting that the 2009 MoU introduced the concept of the "preferred charging rate" (defined as charging a battery from 10% capacity to 90% capacity within a maximum of 6 hours). As part of this study, we have explored whether, instead of or in addition to defining minimum power requirements, a new initiative could include reference to an updated preferred (or minimum) charging rate. However, this was considered suboptimal, as (all other factors being equal) devices with a larger battery capacity take longer to fully charge their batteries. Therefore, according to industry representatives, the definition of an ambitious "preferred" or "minimum" charging rate would unfairly impact devices with larger battery capacities, potentially limiting the provision of high battery capacity devices for consumers.

[64] As noted above, IEC 63002 is currently being updated; according to experts interviewed as part of this study, once the update is complete, it is likely that compliance with this standard will be sufficient to ensure the interoperability of all EPS with all mobile phones (including backwards compatibility with earlier generations of USB specifications). However, this would need to be substantiated in due course, in order to determine whether all relevant features of other standards (in particular IEC 62680 and 62684) are adequately covered.

[65] It should be noted that only a small minority of respondents to the public consultation (13% of all respondents, incl. 15% of responding businesses and business associations) believed that wireless charging would replace wired charging entirely within the next five to ten years.

technologically superior and may therefore become widely (or even universally) used across manufacturers.

Therefore, we will **not include this element among the options to be assessed further**. At the present time, it seems premature to attempt to seek a harmonised solution; the technology is too incipient, meaning there would be a high risk of prematurely selecting specific technologies, and thus curtailing further innovation and market development. Nor is there an obvious problem in this area, or a strong demand from consumers or stakeholders for a common wireless charger.

Product scope

Since its inception, the Commission's initiative has focused on (data-enabled) mobile telephones. However, in view of the fact that chargers can potentially interwork with a variety of electronic and electrical equipment, this study was also tasked with providing an analysis of the "possible indirect impact on the EU market for other small portable electronic devices requiring similar charging capacity."[66] Therefore, as part of the assessment of the impacts of each option, **we explore the extent to which its scope could be extended to other portable electronic devices**, and provide an indication of the likely *indirect* impacts on these (see section 5.6).

Our analysis of different categories of other devices confirms that there is a range of devices with charging requirements / profiles that are broadly similar to mobile phones. This includes tablets, e-readers, wearables (including smart watches and headphones), speakers, cameras and portable video games. On the other hand, laptops have significantly higher power requirements than mobile phones, and are therefore excluded from the scope of the IA.[67]

Decoupling

Another aspect that is worth discussing relates to possible measures to foster decoupling (i.e. the sale of mobile phones without a charger, or only with cable). As noted previously, increased decoupling is a necessary pre-condition for any initiative to achieve a significant positive environmental impact. It could therefore be considered whether the EU should legislate to make decoupling compulsory (i.e. require mobile phones to be sold without an EPS, or even with neither a cable nor an EPS). However, this study **does not consider mandatory decoupling as an option** for the following main reasons:

- It would exceed the scope of the initiative as previously framed in the most recent letter from MEPs, which urges the Commission to make the "common charger" a "reality", thereby "reducing the *necessity* to purchase different types of chargers" and giving "the *possibility* to reuse already owned ones" [emphasis added][68], the Commission's inception impact assessment (which focuses on developing a "common charger" and guaranteeing "full

[66] European Commission (2018): Technical Specifications for the Impact Assessment Study on Common Chargers of Portable Devices

[67] If harmonisation of laptop chargers is to be considered, a dedicated impact assessment would be needed. Given the current status of the market, with multiple charging solutions available, the effects of harmonisation could be very significant, both positive and negative. These effects would need to be analysed in depth and this analysis is not possible within the scope of this study. In addition, it is likely that the "harmonised charger" for laptops would differ significantly from the harmonised charger for phones and similar devices, given the differences in power requirements. This does not preclude, though, that both chargers could be interoperable, albeit with significant differences in performance.

[68] Letter from a number of MEPs to Commissioner Elżbieta Bieńkowska regarding the Common charger for mobile radio equipment, 5 October 2018

interoperability"[69]), the public consultation (which asks respondents for their views on a number of options, but not mandatory decoupling), as well as the Technical Specifications for the present study.[70]

- Thus, there is no clear mandate for the initiative on common chargers to encompass mandatory decoupling. Including such an option would broaden the scope of the study considerably, and could have far-reaching consequences in terms of the nature and scale of the impacts which were not foreseen at the outset, and therefore not built into our approach to the data collection and analysis. It would be very challenging to add this dimension ex post, and attempt to estimate such impacts in a robust and evidence-based way.

- In our view, mandatory decoupling would be a highly interventionist measure (prescribing how manufacturers sell and market their products) for which there is no clear mandate (see above) or obvious legal basis. It would significantly alter the scope of the initiative as previously considered and discussed, in ways that are likely to be highly controversial among not only economic operators but also some consumers (who would no longer have the option of purchasing a "complete" phone, but would have to rely on a charger they already own or purchase separately), and could therefore entail significant risks (e.g. in terms of the EU being accused of excessive "regulatory zeal"). In view of this, we would suggest that, if mandatory decoupling is to be considered further, it would warrant a separate study, with a clear focus on analysing its different effects (whereas the present study focuses on the technical aspects of harmonising charging solutions, which is a very different matter).

However, as part of assessing the (environmental and other) impacts of all of the policy options identified previously, we do estimate the effects on *voluntary* decoupling that are likely to be achieved. For this purpose, we have developed a range of scenarios, drawing on assumptions based to the greatest extent possible on the available evidence (including consumers' willingness to consider buying mobile phones without chargers as expressed in the consumer panel survey). As part of this, we have developed more "pessimistic" and more "optimistic" scenarios (for details see section 5.1).

Timeframe

An important question is when any new rules will enter into force. Longer or shorter transition periods could have an impact on the scale of the (positive as well as negative) impacts of any new initiative. But rather than frame these as separate policy options, we have used the following assumption: Any new rules (whether based on regulation or adopted voluntarily by the industry) would **apply to all mobile phones sold on the EU market from 1 January 2023**. Assuming the initiative would be finalised and adopted in 2020, this provides for a transition period of at least two years before the new rules enter into force. It can then be inferred how a longer or shorter transition period would affect the results.

It should also be noted that, in view of the possibility of further technological evolution (e.g. the development of a possible "USB Type-D" connector), the initiative would have to consider a mechanism for **potential review and/or update** in the future. For the purpose of our analysis, we assume an appropriate review mechanism would be incorporated, and could be used to update the common rules and requirements if

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[69] Cp. the Commission's Inception Impact Assessment, Ref. Ares(2018)6473169 - 15/12/2018

[70] The inclusion of a "mandatory decoupling" policy option was also discussed and explicitly ruled out at the inter-service group meeting on 15 February 2019 to discuss the inception report.

required. However, since it is currently not possible to anticipate when any significant new technologies would become available (and widely adopted), we assume any rules adopted in the first instance would remain in force until at least the end of 2028 (thus covering the entire time span modelled by this study).

Instrument

Finally, the question of the policy instrument that is chosen – voluntary or regulatory action – is obviously of critical importance. However, if one assumes 100% industry compliance with a new voluntary initiative, then its impacts can be expected not to differ from those of a regulation that introduces the same obligations. Therefore, **we treat the question of the most appropriate policy instrument as the second (rather than the first) layer of the analysis**. In other words, instead of considering the policy instrument first, and then asking what specific rules and requirements it would entail, we focus on the technical content of the options first (as outlined above), and assess the likely impacts of, for example, limiting the connectors on the device end to USB Type-C only. As a second step, we then consider:

- The extent to which these requirements would lend themselves to being achieved via a voluntary initiative, and any inherent risks, caveats or adaptations that would be required.
- What legal basis could be considered for pursuing this option via regulatory action, in particular whether it could be achieved via a Delegated Act under Article 3(3) of the RED, or if a different legal basis would need to be found.

4.3 Options shortlisted for in-depth assessment

Following on from the considerations put forward above, in addition to the baseline, the IA study addresses the following policy options in depth:

- Five specific policy options – three of which concern the connectors at the device end, the other two the external power supply (EPS).
- These two types of options are not mutually exclusive – where relevant, we consider the cumulative impacts of harmonising both the device-end connectors and the EPS.
- For each of the five options, we also provide an account of:
  - the main impacts that extending its scope to other portable electronic devices would have, and
  - the likely effectiveness of different instruments, including (a) the potential for achieving the desired level of harmonisation via a voluntary industry commitment, and (b) whether it could be regulated via a Delegated Act under Article 3(3) of the RED, or if a different legal basis would be required.

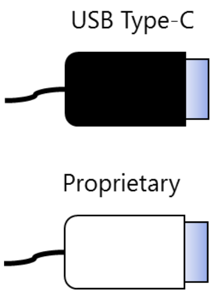
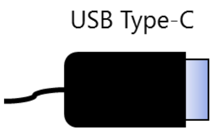
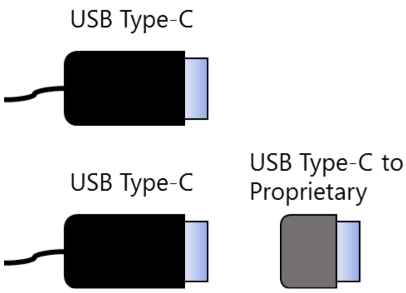
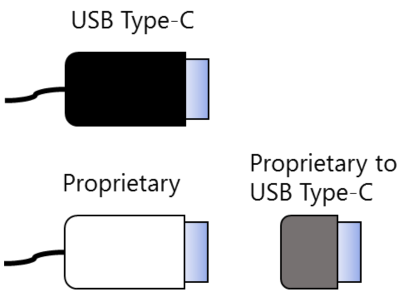
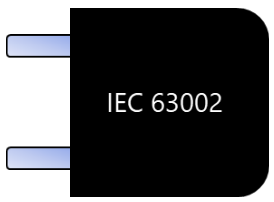
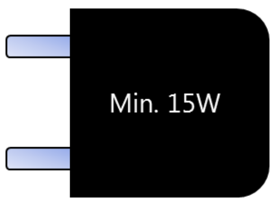
The options and ancillary considerations are summarised in Table 17 below. The main features of each option, as well as a graphical representation of their main features, are provided in

Table 18 overleaf.

Table 17: Summary of the approach to assessing the policy options

	Connectors at the device end				EPS	
Policy options for mobile phone chargers	0. Baseline 2018 MoU: USB Type-C or proprietary, adaptors available to purchase	1. USB Type-C only	2. USB Type-C only; for phones with proprietary receptacles, adaptors in the box compulsory	3. USB Type-C or proprietary; for cables with proprietary connectors, adaptors in the box compulsory	4. Guaranteed interopera-bility of EPS	5. Interopera-bility plus minimum power requirements for EPS
Consideration of scope	N/A	Extend scope to chargers for other portable electronic devices with similar charging requirements to mobile phones?				
Consideration of policy instrument	N/A	Potential for achieving harmonisation via a voluntary industry commitment				
	N/A	Legal basis for possible regulatory action				

Table 18: Detailed overview of policy options

Option	Visualisation	Notes
0. Baseline (2018 MoU)		As per the MoU proposed by industry in 2018, cable assemblies can have either a USB Type-C or a proprietary connector at the device end. It is assumed that adaptors continue to be available for purchase.
1. USB Type-C only		Only cable assemblies with a USB Type-C connector at the device end are allowed. Cable assemblies that require adaptors are not considered compliant.
2. USB Type-C only; for phones with proprietary receptacles, adaptors in the box compulsory		Only cable assemblies with a USB Type-C connector at the device end are allowed. Manufacturers that wish to continue to use proprietary receptacles in their phones are obliged to provide an adaptor from USB Type-C to their proprietary receptacle in the box.
3. USB Type-C or proprietary; for cables with proprietary connectors, adaptors in the box compulsory		Cable assemblies can have either a USB Type-C or a proprietary connector at the device end. Manufacturers that choose to provide a cable with a proprietary connector are obliged to provide an adaptor in the box that enables its use with a USB Type-C receptacle.
4. Guaranteed interoperability of EPS		Commitment (via a voluntary agreement or an essential requirement enshrined in regulation) to ensuring all EPS for mobile phones are interoperable. This would need to be concretised via reference to compliance with relevant USB standards, in particular the interoperability guidelines for EPS (IEC 63002), which are currently being updated.
5. Interoperability plus minimum power requirements for EPS		To facilitate adequate charging performance, all EPS for mobile phones would have to guarantee the provision of at least 15W of power (in line with most current fast charging technologies). To also ensure full interoperability, all EPS would have to be capable of "flexible power delivery" in accordance with common (USB PD) standards / specifications.

5. IMPACT ASSESSMENT

This chapter provides an estimation of the most significant impacts of each of the policy options shortlisted for in-depth assessment. Quantitative or (where this is not feasible with the information and methodologies at hand) qualitative estimates are made based on the available primary and secondary data, and a range of assumptions to fill gaps and model the likely effects of the different options.

This chapter starts by defining scenarios for decoupling (which are relevant to assessing a number of impacts). It then goes on to analyse the main social (5.2), environmental (5.3), and economic (5.4) impacts we expect the initiative to have (the most relevant impacts were selected based on an initial screening of a wide range of types of impacts). The chapter ends with a discussion of a number of issues that are important to consider when it comes to the implementation, including the technical feasibility and acceptability of the options, potential indirect impacts on other portable electronic devices, and consideration of the policy instrument (regulatory or voluntary action).

5.1 Decoupling scenarios

As noted previously (and discussed further in the ensuing sections), one of the key drivers of the likely impacts of any initiative to harmonise chargers is the extent to which it leads to decoupling, i.e. the sale of phones (and potentially other types of portable electronic devices) without a charger. Without a mandatory requirement for manufacturers and distributors to decouple chargers from phones (which could be considered in principle, but falls outside of the scope of this study, as discussed in section 4.2 above), the decoupling rates achieved will depend on "organic" market developments, namely the extent to which manufacturers and distributors decide to offer phones without chargers in the box, and the extent to which consumers choose to purchase these. This is inherently difficult to predict. For this study, we have to rely on a number of **assumptions and scenarios**, based to the extent possible on the available evidence. However, it is important to emphasise that these are subject to a high degree of uncertainty; we can consider the decoupling rates that appear possible under different scenarios, and the likelihood that different policy options might help to achieve these rates, but not make any definitive predictions about how the market will evolve.

<u>Key factors for consideration</u>

As briefly outlined previously (see section 3.3), the extent to which **mobile phones are currently sold in Europe without chargers** is negligibly small. In the past, schemes to sell certain phones without an EPS (but including a cable) were trialled by Motorola and by the UK network carrier O2 around 2013, but despite some early successes,[71] both appear to have been discontinued. At present, to the best of our knowledge, the only company in Europe to actively promote decoupling is Fairphone, which sells all its phones without a charger (EPS or cable) by default, mainly in an effort to reduce e-waste, and claims that only around 25% of its customers opt to add a charger to their order. However, Fairphone's share of the European mobile phone market is too small to figure in the IDC shipments data for 2018.

Some **other portable electronic devices** are currently being sold with only a cable, but no EPS. This was the case of the majority of the action cameras, wearables, and

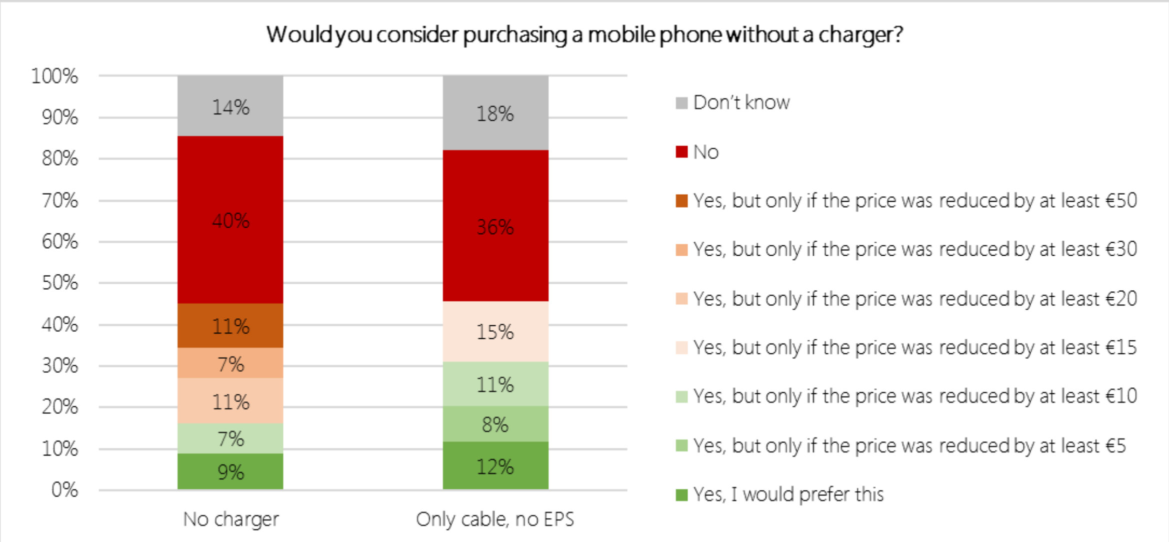
[71] RPA (2014), pp. 24-25

e-readers in the sample we reviewed (see section 3.4). This suggests there is scope for potentially extending such an approach to mobile phones. However, it should be noted that, according to manufacturers, the decision not to ship these devices with an EPS is often partly motivated by the assumption that nearly all consumers own a mobile phone, and will be able to use their mobile phone charger for these devices as well. Therefore, a widely held view among industry stakeholders is that the situations are not directly comparable.

In the **consumer panel survey**, respondents were asked whether they would consider purchasing a mobile phone without a charger. 40% categorically ruled out purchasing a phone without a charger, and 36% also ruled out purchasing a phone with only a charging cable, but no EPS included (see the figure below). The main reasons provided for the insistence on a charger being included in the box were not having to worry about how to charge the phone, and that it ensures that the charger works well and is safe. Older respondents (aged 45 or older) were a little (around 4%) more likely to rule out the purchase of a phone without a charger (or EPS) than younger ones. There was no significant difference between users of iPhones and users of other phones.

On the other hand, 12% of survey respondents stated they would actually prefer to purchase a phone with a cable but no EPS, and 9% would prefer a phone with no charger at all. The remainder responded they would be willing to consider this, but only if it meant the price of the phone (or the overall cost of the contract over its duration) was reduced by at least EUR 5 (cable only) or at least EUR 10 (no EPS or cable). However, when interpreting these responses, it should be noted that some of the higher discounts respondents stated would be needed for them to consider buying a phone without a charger (up to EUR 50) appear unrealistic, given the actual prices of chargers (see section 5.4 below). When asked why they would consider buying a mobile phone without a charger, in addition to saving money, significant numbers of these respondents also mentioned environmental concerns (a desire to save resource and reduce electronic waste) and convenience benefits (as they claim to already have too many chargers).

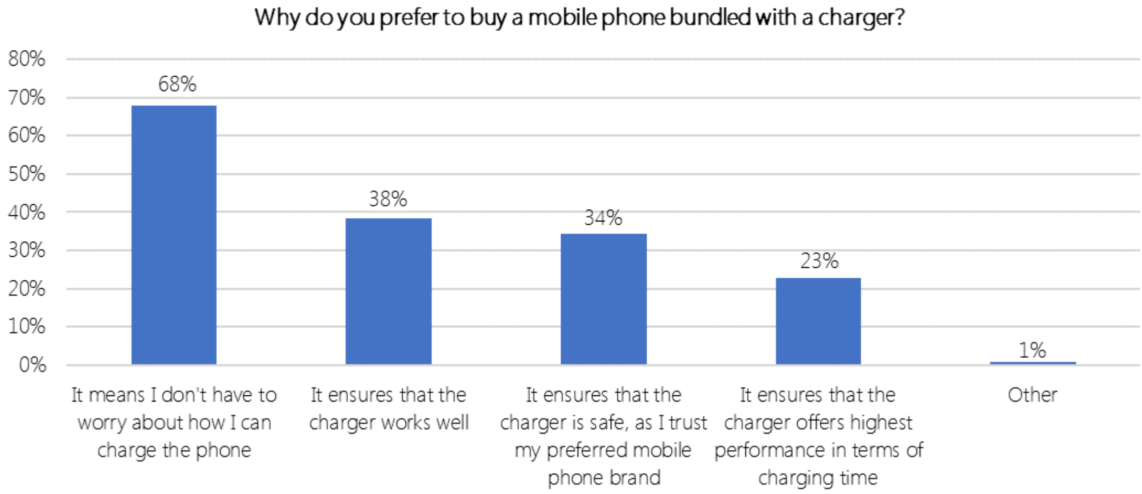
Figure 26: Consumer willingness to consider decoupling



Source: Ipsos consumer panel survey, N = 5,002
NB: The "Yes, but…" response options in the legend above are abridged for better readability. The full text of all these response options read: "Yes, but only if it meant the price of the phone / the overall cost of my contract over its duration was reduced by at least EUR …"
The price increments provided were different for the two questions: between EUR 10 and EUR 50 for phones "without a charger, i.e. with neither external power supply nor cable assembly

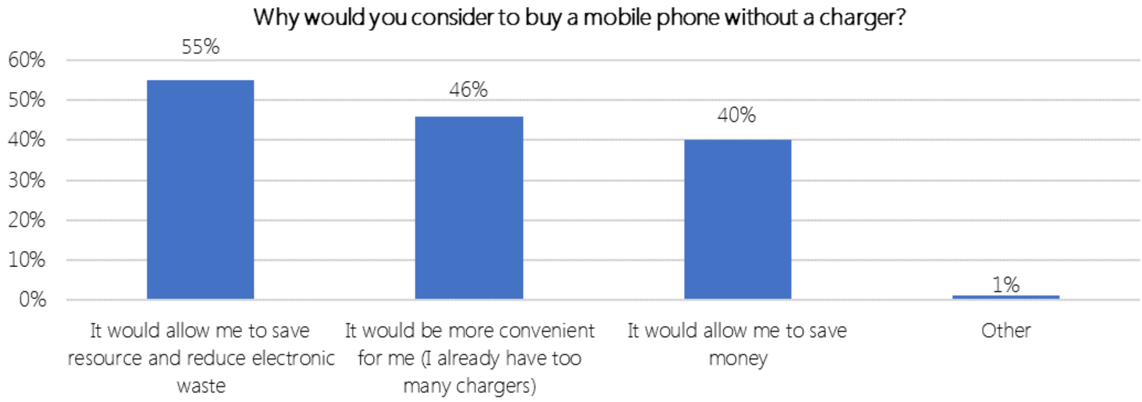
provided"; and between EUR 5 and EUR 15 for phones "with only a charging cable provided, and no external power supply included".

Figure 27: Main reasons why consumers are unwilling to consider decoupling



Source: Ipsos consumer panel survey, N = 2,097

Figure 28: Main reasons why consumers would consider decoupling



Source: Ipsos consumer panel survey, N = 2,189

Most **industry stakeholders** were somewhat sceptical of the potential for extensive decoupling. Many argued that consumers expect a charger in the box (which is only partly confirmed by our survey results), and that having a fully operational phone in the box is an important part of the consumer experience, particularly with high-end devices. Mobile manufacturers also expressed concerns about the lack of control decoupling would entail – in particular the risk of consumers using inappropriate and/or sub-standard chargers, which not only lead to sub-optimal charging performance, but can also cause damage to the battery as well as potentially serious safety issues (see section 3.9). These concerns are reportedly more pertinent for mobile phones (again, in particular for high-end ones) than for the other devices that are sometimes sold without EPS at present (see above) because mobiles are not only more expensive (on average), but also require more frequent (typically daily) charging, often at faster speeds (which requires higher power and therefore amplifies the risk). In this context, industry stakeholders also raised concerns about the potential implications for the safety testing and certification process (as, according to some interviewees, phones and accompanying chargers are usually tested and certified together, and some stakeholders were unclear how this process would work if there was no charger 'in the box'), and worried about questions of reputational damage from, as well as accountability and responsibility for, any performance or safety issues that might arise, as they believed consumers would ultimately tend to blame (and potentially seek compensation from) the phone manufacturer (rather than the charger manufacturer) for any damage caused. Other concerns mentioned included the useful life of the charger, which may need to be replaced as frequently as the mobile phone, and the fact that consumers use mobile phone chargers to charge other devices.

Scenarios and key underlying assumptions

In light of the factors and evidence briefly outlined above, we have developed a set of decoupling scenarios to help analyse the potential impacts of the different policy options for a common charger. While none of the options involve an explicit commitment or obligation to decouple chargers from phones, the options have the potential to contribute to increasing decoupling rates by achieving further harmonisation and ensuring interoperability of chargers. In general terms, this can be expected to enhance both the awareness of consumers that chargers can be used across a range of devices, and their saturation rate with interoperable chargers (i.e. the extent to which they have access to / are "saturated" with a sufficient number of compatible chargers), and thereby reduce their demand for a new charger in the box with each new phone they purchase. In order to estimate the effects of this, we have taken a **two-step approach**:

1. First, we have developed a set of 'generic; decoupling cases, for both EPS and cables, to reflect a range of more or less optimistic scenarios around how much decoupling appears achievable. These scenarios are described in the remainder of this section.

2. Second, we have linked these scenarios to the different policy options, by considering the potential of each option to achieve the decoupling rates estimated under the first step. This is further discussed in the final part of this section.

The three scenarios (first step) are described below, representing a range of more or less optimistic outcomes over time. All three scenarios are based on a set of **common assumptions**, namely:

- Main charger components: For a number of reasons, it is 'easier' to sell phones with only a cable than it is to sell them with no charger at all (no EPS or cable). This is partly due to the typically higher cost of the EPS compared with cables (meaning there are more significant savings from decoupling), as well as the fact that the cables are not only used for charging, but also for data transfer. The greater openness of consumers to purchase devices with a cable but no EPS is also reflected in the fact that certain devices are already routinely sold with only a cable, and confirmed by the results of our consumer panel survey (see above). Therefore, we have assumed the decoupling rate for cables to be half that for EPS across all scenarios.

- Current decoupling rate: As noted above, the extent to which mobile phones are sold without chargers in Europe at the moment is negligible: Fairphone is the only supplier we are aware of, with a market share significantly below 0.1%. In our consumer panel survey, a little over 1% of respondents claimed to have purchased at least one charger in the last five years because their mobile phone did not include a charger, but this figure is unlikely to be an accurate reflection of the market (e.g. it may well include second-hand phones, which are more likely to be sold without a charger). Therefore, as the baseline for our estimates, we assume that, in 2020, 0% of phones are sold without EPS or cable.

- Evolution of decoupling rates over time: As noted previously (section 4.2), we assume that any new rules stemming from the policy options would apply to all mobile phones sold on the EU market from 1 January 2023. Considering this, as well as the apparent market trend (gradual substitution of 'legacy' USB connectors with USB Type-C connectors at both the device and EPS end – albeit much more slowly for the latter), we therefore assume that, as the markets adapt to the new rules, and consumer saturation with compatible chargers increases, decoupling rates will start to increase from 2021, and reach the maximum rates under each scenario by 2023. They then remain constant for three years, before beginning to drop (by 20% per year), reflecting the likely emergence of newer technologies and standards, and hence the need for consumers to adapt to a new 'generation' of charging solutions.

The lower case scenario

The first scenario is the most pessimistic one (though still more optimistic than the baseline, which assumes no increased decoupling). It assumes only very limited growth in decoupling rates, as a result of the greater consumer saturation with interoperable chargers leading some manufacturers and/or distributors to offer mobile phones without chargers in certain market segments. However, in this scenario, decoupling would remain the exception, as most major market players would continue to include a charger (both cable and EPS) in the box of all of their phones. As such, the decoupling rates achieved under this scenario do not exceed 5% for EPS, and 2.5% for cables.

Table 19: Decoupling rate assumptions: lower case

	2020	2021	2022	2023	2024	2025	2026	2027	2028
No EPS	0%	2%	3%	5%	5%	5%	4%	3%	2%
No cable	0%	1%	1.5%	2.5%	2.5%	2.5%	2%	1.5%	1%

The mid case scenario

The second scenario is intended to provide a realistic (but by no means certain) projection in which manufacturers and distributors increasingly cater to the preferences of those consumers who prefer to purchase mobile phones without chargers. It assumes the emergence of a significant number of schemes that allow consumers to opt out of having an EPS and/or cable included in the box of their new phones, potentially in return for a small discount (which, in view of the production cost of chargers, would be very unlikely to exceed EUR 5). However, the coverage of such schemes would not be universal, and their take-up would remain limited to consumers with a high awareness of the interoperability of charging solutions, and the environmental implications of the production and disposal of large numbers of (unnecessary) chargers. Broadly in line with the results of our consumer survey (for respondents who would prefer to purchase phones without chargers even without a discount), this would result in a decoupling rate of 15% for EPS, and 7.5% for cables, by 2023.

Table 20: Decoupling rate assumptions: mid case

	2020	2021	2022	2023	2024	2025	2026	2027	2028
No EPS	0%	5%	10%	15%	15%	15%	12%	9%	6%
No cable	0%	2.5%	5%	7.5%	7.5%	7.5%	6%	4.5%	3%

The higher case scenario

The third (and most optimistic) scenario is intended to reflect the "maximum possible" decoupling rate that appears achievable, assuming full buy-in from manufacturers and distributors, and an increased willingness of consumers to re-use chargers they already own to charge their new phones. Achieving this buy-in is likely to require not just a harmonisation of charging solutions, but also certain supporting measures (for further details on such measures, see the end of this section).

Under the higher case scenario, we assume a maximum decoupling rate of 40% for EPS, and 20% for cables. This reflects the fact that, given consumer preferences, ownership of interoperable chargers from other phones or devices, and the lifetime of chargers, there will always continue to be demand for a significant number of new chargers. This decoupling rate is consistent with the results of the 2014 RPA study[72], as well as the fact that around half of respondents to our consumer survey (not counting those who responded "don't know") stated they would not consider buying a phone without a charger even if it was significantly cheaper.

Table 21: Decoupling rate assumptions: higher case

	2020	2021	2022	2023	2024	2025	2026	2027	2028
No EPS	0%	10%	25%	40%	40%	40%	32%	24%	16%
No cable	0%	5%	12.5%	20%	20%	20%	16%	12%	8%

It is important to reiterate that none of these scenarios should be interpreted as firm predictions. Increased decoupling rates would not be a *direct* consequence of the policy options as defined within the scope of the present study, and as such, any predictions regarding how the markets would react are **subject to significant uncertainty**. Nonetheless, in what follows, we provide an assessment of the likelihood of and extent to which the different options could help to achieve the scenarios outlined above.

The potential effects of the policy options on decoupling rates

As discussed at length previously, the policy options relate to harmonising different elements of charging solutions, namely the connectors at the device end, and the external power supply (EPS). None of these options would lead directly to higher decoupling rates. However, if implemented, such harmonisation is expected to contribute to making decoupling more attractive to consumers (as their saturation with compatible charging solutions, as well as their awareness of and confidence in the

[72] Cp. RPA (2014). According to RPA, 50% of devices sold without a charger is seen as the highest possible rate, based on the levels of ownership of devices at the time and expected charging behaviour of consumers. However, it notes that in product sectors which are characterised by a high innovation and short product lifecycles, the 50% rate may never be achieved.

interoperability of chargers increases), which in turn could lead more economic operators to make available 'unbundled' solutions on the EU market (assuming their other concerns can be addressed).

In the table below, we consider the extent to which the preconditions for increased decoupling are likely to be affected under each of the specific policy options being considered, and hence which of the scenarios outlined above appears most relevant. The scenarios resulting from this should be seen as the "best case" for each option, rather than a firm prediction. In other words, for example, while we cannot be sure that option 1 would lead to a certain decoupling rate, we conclude that, in isolation (i.e. without any other accompanying measures), a common (USB Type-C) connector at the phone end would be very unlikely to lead to anything more than the lower case scenario as defined previously.

Table 22: 'Best case' decoupling assumptions under each policy option

Elements	**Options**	**Notes**	**Best case decoupling scenario**
Baseline	Option 0	The baseline scenario assumes no further harmonisation of charging solutions, and hence no increase in the current decoupling rates, which is so low (likely in the range of 0.01%) as to be negligible for the purpose of our analysis.	Status quo (no decoupling)
Device-end connectors	Option 1	If only cable assemblies with a USB Type-C connector at the device end are allowed, this would obviously make all cables interoperable across all phone manufacturers and models. However, as cables are intrinsically less likely to be unbundled (given they also fulfil data transfer functions), this alone is unlikely to significantly increase demand for decoupled solutions. Therefore, we conclude that this option is unlikely to achieve decoupling rates beyond the lower case scenario.	Lower case (max. 5% for EPS, 2.5% for cables)
	Option 2	The possibility for manufacturers who wish to use proprietary receptacles in their phones to make this interoperable with the USB Type-C connector on the cable by including an adaptor in the box makes no material difference to the decoupling scenarios as such. Like option 1, it increases consumer saturation with compatible cables, but is subject to the same limitations.	
	Option 3	Allowing manufacturers to provide cables with proprietary connectors, but requiring them to include an adaptor in the box to make the cable usable with devices that have USB Type-C receptacles, would also increase consumer saturation with interoperable cables (although in some cases an adaptor would be required). Thus, like options 1 and 2, we assume it would lead to a modest increase in decoupling rates.	

Elements	Options	Notes	Best case decoupling scenario
EPS	Option 4	As noted previously, the majority of EPS for mobile phones are already interoperable. A commitment to ensure this continues to be the case for all EPS (i.e. all EPS comply with the relevant standards) would provide guarantees going forward, and could further enhance consumer awareness of and confidence in their ability to re-use their existing EPS. Since decoupling tends to be more common for the EPS than for the cables, a more significant increase in decoupling rates could be expected under this option.	Mid case (max. 15% for EPS, 7.5% for cables)
	Option 5	Under this option, all EPS would not only be interoperable, but the minimum power requirements would also guarantee consistently high charging performance. This would eliminate an important barrier to the re-use of existing EPS with other (new) mobile phones, and reduce the need for consumers to consider variations in charging speed. However, more power produces more heat, which can affect battery life and give rise to safety issues. This would be likely to make manufacturers more reluctant to sell phones without chargers, and have to rely instead on chargers bought by consumers separately (which may not comply with all safety standards) or with previous phones. We assume these two effects would cancel each other out, and this option would achieve similar decoupling rates to option 4 above.	Mid case (max. 15% for EPS, 7.5% for cables)
Combination	Option 1 + Option 4 or 5	An intervention that guarantees the interoperability of both the cables and the EPS clearly has higher potential to facilitate increased decoupling rates than either element in isolation, due to the likely greater impacts on consumer saturation with compatible charging solutions as a whole, and their acceptance that chargers work across different types of phones / devices. Therefore, if options 1 and 4 (or 5) were both taken forward, the higher case scenario seems achievable, provided appropriate accompanying measures are taken to encourage both consumers and the industry as a whole to embrace decoupling.	Higher case (max. 40% for EPS, 20% for cables)

As can be seen in the table above, the potential for most options to achieve significantly increased decoupling rates appears relatively limited. The highest possible rates only appear plausible as a result of the maximum harmonisation options for both the device-end connectors and the EPS. Even then, it is important to emphasise again that this is the best case scenario, and depends on a range of factors, in particular the commercial and other decisions made by mobile phone manufacturers and distributors, which are inherently difficult to predict. The experience of the 2009 MoU suggests that harmonisation of charging solutions might be *helpful* to foster decoupling, but is unlikely to be *sufficient* without accompanying measures by the Commission and/or other public authorities to enable, foster and/or incentivise increased decoupling. Therefore, whenever we refer back to the achievable decoupling rates in the ensuing sections, the very high degree of uncertainty regarding these should be kept in mind.

Other possible measures to facilitate decoupling

Given that (1) none of the options considered as part of this study on its own appears likely to achieve significantly increased decoupling rates, and (2) decoupling appears most likely to address the environmental problems caused by the current situation (for details see section 5.3 below), it may be appropriate to consider other measures that could be considered to facilitate decoupling. While this was not the main subject of this study (which, as noted previously, was to focus on elements of a "common charger"), in what follows we provide a few high-level, indicative thoughts and ideas on this which, if the Commission were to decide to pursue such a course of action, would need to be studied in far greater detail.

We are not aware of any obviously relevant precedents (i.e. directly comparable initiatives in other sectors or parts of the world). However, in general terms. relevant studies[73] have identified four main categories of policy tools to encourage "green" behaviour (regulatory, economic, information, and behavioural). In the specific case of decoupling chargers from mobile phones sales, each of these could entail:

- **Regulatory**: This includes mandatory tools that ban or limit certain products or behaviours. In this particular case, it is difficult to envisage an effective regulatory intervention, beyond an outright ban on the sale of chargers with phones, which appears disproportionate and potentially counterproductive (for the reasons already discussed in section 4.2). Legally obliging distributors to offer consumers the *option* of acquiring a phone either with or without a charger (EPS and/or cable) would be a slightly less interventionist approach, but would nonetheless represent a significant intervention in the market, the implications of which would need to be considered very carefully.

- **Economic**: This category includes market-based instruments that influence purchasing decisions through taxes, incentives, subsidies, penalties or grants for green enterprises. In principle, tax breaks or other fiscal incentives for phones sold without chargers could be explored, although these appear difficult to implement in practice at EU level, given the EU does not have a direct role in collecting taxes or setting tax rates. Softer economic incentives could include demand-side measures, such as enhancing demand via public procurement (i.e. the purchase of mobile phones without chargers by public authorities). In order to create economic incentives for consumers, it may be necessary to also consider how the authorities can ensure that any cost savings from not providing a charger in the box are actually passed on to consumers.

- **Information**: This would entail measures to stimulate demand for "unbundled" solutions, by enhancing awareness of the interoperability of chargers, and the environmental benefits of reducing their numbers. From the perspective of consumers, our survey (see Figure 27) suggests that by far the most important reason why most prefer to buy a mobile phone bundled with a charger is convenience (i.e. not having to worry about how to charge the phone), rather than concern about the functioning or safety of chargers. It might be possible

[73] See for instance Sonigo et al (2012): Policies to encourage sustainable consumption, Final report prepared by BIO Intelligence Service for European Commission (DG ENV). Available at: http://ec.europa.eu/environment/eussd/pdf/report_22082012.pdf

to change consumer priorities and preferences to a certain extent via targeted information / education campaigns, focusing on the environmental benefits of decoupling (both the consumer survey and Public Consultation suggest that consumers could be receptive to such messages). Any residual concerns about the interoperability and/or safety of chargers could also be addressed as part of such campaigns. Furthermore, if options 4 or 5 were pursued, it would be worth considering whether new / enhanced labelling and/or certification requirements could help enhance consumer awareness of and confidence in the interoperability of EPS, and by extension, their openness to consider purchasing a new phone without a (complete) charger. For example, it could be explored if and how a new label on EPS (e.g. "USB PD compatible") could be introduced to help users understand which EPS works with what devices.

- **Behavioural**: This final category includes tools or "nudges" aimed at influencing consumer behaviour to make choices that are better for the environment. Examples in other fields include comparative information on energy bills, pledges to adopt certain behaviours, and making pro-environmental alternatives the default. As such, certain behavioural levers could be similar to some of the tools mentioned previously, e.g. working towards making sales of phones without chargers (in particular EPS) the *default*, while always giving consumers the *option* of purchasing a charger with it (potentially choosing from a range of more or less sophisticated chargers), or changing the way information on interoperability is presented and framed (e.g. via labels). Other "nudges" could also be considered, such as providing information about a device's environmental footprint (clearly showing the advantages of decoupled solutions). For example, the Commission recently explored whether provisions could be included in the new ecodesign regulation for a certain category of products to give a better energy efficiency rating to products that do not include accessories in the box. Similar considerations could apply to mobile phone chargers.

If any of these potential tools is pursued further, it will be important for the European Commission and/or national authorities to work proactively with the industry to encourage (and, if possible, incentivise) it to participate. For this purpose, it could be useful to establish discussions with phone manufacturers as well as distributors, to further explore lessons that can be learned from past decoupling initiatives that were discontinued, and consider if and how public authorities could help address the main barriers to decoupling from the perspective of the industry. For example, it might be worth considering if and how phone manufacturers' concerns about an increase in the use of substandard third-party chargers, and the potential reputational and financial risks to them from any damage caused by these to their phones, could be alleviated (e.g. by stricter controls on online sales, or by clarifying the burden of proof to determine the liability in such cases).

5.2 Social impacts

The most relevant (i.e. potentially significant) social impacts of the initiative, which are discussed in this chapter, are:

- Consumer convenience benefits from increased harmonisation of charging solutions[74]
- Impacts on product safety, in terms of the risk of injury or damage to consumers
- Impacts on the illicit market for mobile phone chargers (which is a criminal activity) and its effects

Consumer convenience

As discussed previously (see section 3.5 for details), our survey of a representative panel of consumers suggests that around eight in ten EU consumers have experienced some form of inconvenience in relation to mobile phone chargers. When considering different sources of inconvenience, between around one third and one half of EU consumers have experienced each of a series of issues causing them inconvenience at least once over the course of the last two years.[75] Broadly speaking, the sources of consumer inconvenience identified via the survey can be divided into four sets of issues, with those experienced by the highest number of consumers listed first:

a) **Inability to charge certain devices (as fast) with certain chargers**: This relates to three broadly similar problems, each of which was experienced by around half of all survey respondents: not being able to charge their new phone with their old charger (46%), not being able to charge their phones *as fast* with another charger (53%), and not being able to charge other electronic devices with their phone charger (49%). A little under half of those who had experienced these problems felt that this caused significant issues, meaning that the proportion of *all* respondents who had experienced each of these problems at least once, and for whom they had cause significant issues at least from time to time, was slightly over 20%.

b) **Too many chargers:** This includes two of the response options in the survey. The results suggest that a little over half (53%) of consumers feel they have too many chargers taking up space in their home and/or workplace, but only around four out of ten of these (or 21% of all respondents) considered this to cause significant issues. In a similar vein, 40% reported that, on at least one occasion, they were provided a new charger with a new phone when they would have preferred to keep using a charger they already had; but only a little over a third of these (or 15% of all respondents) thought this was significant.

c) **No access to a compatible charger**: Three out of eight survey respondents (38%) reported having been in a situation where they needed to charge their phone, but the available chargers were incompatible with it. Out of these, half

[74] The effects on the cost of chargers to consumers are analysed as part of the assessment of economic impact in section 5.4.

[75] As noted in section 3.5, respondents to the Public Consultation reported broadly similar levels and types of inconvenience, but consistently rated these as more serious / significant than participants in the consumer panel survey. Since the panel survey was conducted with a representative sample of consumers, it is more likely to provide an accurate picture of how "typical" EU citizens feel about the issues at hand, and was therefore used as a basis for the ensuing analysis.

(19% of all respondents) had only experienced this once or twice in the last two years, while four out of ten (15% of all respondents) had experienced this on a few occasions, and around one in ten (4% of all respondents) on numerous occasions. When asked about the seriousness of this problem, 49% of those who had experienced it (or 19% of all respondents) reported it had caused them significant issues.

d) **Confusion about which charger works with what**: Finally, two of the problems experienced by survey respondents relate to confusion, with around a third of survey respondents having been confused about which charger to use for which mobile phone (30%) or other portable electronic device (35%). Compared with the issues covered above, confusion tends to arise less frequently (only 6% had experienced this on numerous occasions or almost every day). Nonetheless, regarding both mobiles and other devices, about half of these who had experienced confusion (or 15-17% of all respondents) reported this had caused them significant issues from time to time.

In summary, annoyance at having too many chargers for mobile phones and other portable devices, and at the lack of interoperability between them, appear to be the main sources of inconvenience, experienced at least occasionally by around half of consumers. Situations where consumers are unable to gain access to a suitable charger for their phone, or are confused about which charger can be used for which phone or device, occur relatively less frequently (around one in three consumers).

Nonetheless, the proportion of respondents who reported having experienced *significant* issues was quite similar across all of the problems listed (between 15% and 22% of all respondents). It therefore **appears justified to attach the same significance to each of the four sets of issues** for the sake of the impact assessment. In the remainder of this section, we consider how the different policy options would be likely to affect consumer (in)convenience of the four main types outlined above. The main results are summarised in the table below.

Table 23: Main effects of the policy options on consumer convenience

	Connectors at the device end			**EPS**	
Sources of inconvenience	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option 5**
a) Inability to charge certain devices (as fast)	+ Enhanced ability to charge all phones with the same cables	+/- As option 1, but some users need to rely on adaptors to charge their main phone	0/+ Adaptor enables some users to charge other phones / devices	+ Guarantees the EPS will work with all phones	++ As option 4, plus guaranteed high performance
b) Too many chargers	0 No benefit from the options per se (without increase in decoupling rates)				
c) No access to a compatible charger	++ Increases likelihood of finding compatible charger for all users	+ Increases likelihood for some users only if an adaptor is available	0/+ Increase likelihood for some users in specific situations only	0/+ Most EPS already interoperable; benefits on few occasions only	

	Connectors at the device end			EPS	
Sources of inconvenience	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option 5**
d) Confusion about which charger works with what	0 Negligible impact, as amount of confusion from connectors seems very limited (except among the visually impaired)			++ Guaranteed interoperability of EPS across phones, and increased consumer awareness of this	
Overall effect on consumer convenience	**+**	**0**	**0**	**+**	**+**

++ Major positive impact *+ Minor positive impact* *0 No or negligible impact* *- Minor negative impact* *-- Major negative impact*

Option 1

A common universal USB Type-C connector at the phone end could be expected to affect the main sources of consumer (in)convenience as follows:

a) **Inability to charge certain devices (as fast) with certain chargers**: Minor positive impact. The common connector would ensure that consumers can use the cable supplied with their mobile phone to charge any mobile phone irrespective of the brand or model, and potentially also a wide range of other portable electronic devices (for details on this see section 5.6). While this is expected to be the case anyway for the majority of consumers (the baseline scenario foresees a convergence of large parts of the market towards USB Type-C connectors), this option would eliminate proprietary connectors and thus extend the benefits to all users, eventually ensuring that *all* cables can be used to charge *all* phones. However, it should be noted that, during the transition, there would be a one-off negative effect on some users: when current Apple users purchase the first new phone that complies with this requirement, the effect will be the opposite, i.e. they will not be able to charge their new phone with their old (Lightning) cable. This option also does not have any effects on the existing variations in charging performance, i.e. would not ensure users can charge their phones at the same speed irrespective of the charger they use.

b) **Too many chargers:** No impact. The number of chargers owned by consumers would not be reduced by the harmonisation of connectors. Instead, it is a direct function of the decoupling rates achieved. As outlined previously (see section 5.1), it is possible that a small increase in the proportion of phones sold without chargers would result from this option, but this is too uncertain to incorporate into the analysis of the impacts of the option per se.

c) **No access to a compatible charger**: Major positive impact, especially for users whose phones currently have proprietary connectors. A common connector at the device end would increase the likelihood that users who run out of battery, but have no access to their own charger (e.g. because they are travelling), are able to find a compatible charger. The likelihood would be most significantly increased for the minority of users whose phones currently rely on proprietary connectors. In other words, Apple users (currently a little over 20% of all mobile phone users in the EU) would be *much* less likely to find their ability to charge their phones constrained by incompatible cables, while the remainder of mobile phone users would be *a little* less likely to encounter this problem. However, it should be noted that, according to the survey results, lack of access to a compatible charger is a relatively infrequent occurrence (see above). Furthermore, it is important to keep in mind that a common connector would only provide convenience gains for consumers who find themselves in specific situations that meet all of the following conditions:[76]

- The consumer is not at a "usual" location, such as place of work or home, where he/she has taken steps to have his/her own charging equipment available; and
- The consumer has not carried his/her own charging equipment; and
- The consumer's mobile phone battery has expired or is about to expire, and so requires re-charging to avoid constraining the consumer's use of his/her phone; and
- There is a charging point available to be used with a charger (i.e. the consumer is not outdoors or in another public place where there are no charging points available for use); and
- There are one or more available chargers provided by a third party, none of which would have been compatible with the consumer's phone in the absence of this policy option.

d) **Confusion about which charger works with what**: Negligible impact. Although this was not specifically asked in the survey, it appears safe to assume that confusion arises primarily about the use of different EPS (whose appearance is identical, but most consumers have very limited knowledge of what is inside), whereas the interoperability of differently shaped connectors with different receptacles should be obvious to most consumers. Some exceptions may apply in the case of consumers with a sensory (especially visual) impairment, who might struggle to distinguish different types of connectors, and could therefore benefit from reduced confusion under this option.

Option 2

This option also creates a common USB Type-C connector at the phone end of the cable assembly, but gives manufacturers who wish to use proprietary receptacles in their phones the possibility to make these interoperable with the cable by including an adaptor in the box. The impacts on consumer convenience would differ from those of option 1 above in the following main ways:

a) **Inability to charge certain devices (as fast) with certain chargers**: Minor positive as well as negative impacts for different types of consumers. In general, the proliferation of cables with USB Type-C connectors would increase users' ability to use these to charge a wider range of phones, and thus reduce inconvenience, as described above. However, the net effect is less clear for users of phones with proprietary receptacles (in case certain manufacturers, in particular Apple, were to continue to use these), as the increased ability to use the charging cable for other phones would be at least partly offset by the inconvenience caused by having to use an additional accessory – namely the adaptor – each time they charge their main phone.

[76] These conditions are based on CRA (2015): Harmonising chargers for mobile telephones

b) **Too many chargers:** No impact. Option 2 (like option 1) might result in a small increase in the proportion of phones sold without chargers (see section 5.1), but this is a possible indirect effect that is subject to a very high degree of uncertainty, and therefore best not incorporated into the analysis of the impacts of the option per se.

c) **No access to a compatible charger**: Minor positive impact. For the majority of mobile phone users, the effect of this option is largely identical to that of option 1 above. However, users of phones with proprietary receptacles would only benefit if they either carry their own adaptor with them, or the correct adaptor happens to be provided by the third party whose charger is being used – both of which seems relatively unlikely.

d) **Confusion about which charger works with what**: Negligible impact. As outlined under option 1, confusion about the interoperability of different connectors with different receptacles is likely to be very rare.

Option 3

If manufacturers are allowed to continue to provide cables with proprietary connectors, but obliged to include an adaptor in the box to make the cable usable with devices that have USB Type-C receptacles, the effects on consumer convenience would differ from those of option 1 in the following main ways:

a) **Inability to charge certain devices (as fast) with certain chargers**: Minor positive impacts for some consumers only. By taking advantage of the adaptor provided, users of phones with proprietary receptacles could use the corresponding charger to also charge other devices (incl. phones) with USB Type-C receptacles. However, the majority (currently nearly 80%) of users who only own mobile phones that come with USB Type-C receptacles (and the corresponding cables) would reap no benefits from this option.

b) **Too many chargers:** No impact, for the same reasons discussed under the first two options (see above and section 5.1).

c) **No access to a compatible charger**: Negligible / minor positive impact. As cables with proprietary connectors would still be in use, this option increases the likelihood that consumers are able to find a compatible charger only marginally. The effect would be limited to the relatively unusual scenario in which a user of a phone with a USB Type-C receptacle happens to come across a third-party charger with a proprietary connector plus an adaptor. In all other scenarios, there would be no benefits from this option.

d) **Confusion about which charger works with what**: Negligible impact. As outlined under option 1, confusion about the interoperability of different connectors with different receptacles is likely to be very rare.

Option 4

This option would ensure all EPS for mobile phones are interoperable by mandating compliance with the relevant international standards. This would be likely to affect consumer convenience as follows:

a) **Inability to charge certain devices (as fast) with certain chargers**: Minor positive impact. As outlined previously, EPS shipped with mobile phones can typically already be used to charge a wide range of other phones / devices. However, there are no guarantees of this, and the survey responses suggest that many consumers' awareness of the extent to which EPS are interoperable with different phones is limited. This option would ensure all modern EPS work with all modern mobile phones. Over time, this would enhance consumer awareness of and confidence in their ability to use their EPS across not only mobile phones, but potentially also a range of other devices that implement the relevant USB standards (especially if accompanying information measures were taken to communicate the new requirements widely), and thereby significantly reduce this source of inconvenience (especially if action was taken simultaneously to address connectors, as per the first three options) – although it should be noted that charging speeds may still vary.

b) **Too many chargers:** No impact. A reduction in the number of chargers owned by consumers would only occur as a result of decoupling. Although we assume this option *could* result in a more significant increase in the proportion of phones sold without chargers compared with the options discussed above (see section 5.1), this effect is highly uncertain, and therefore not incorporated into the impact analysis as such.

c) **No access to a compatible charger**: Negligible / minor positive impact. As noted above, most EPS sold with mobile phones are already interoperable with a wide range of different phones. In situations where consumers require access to a third-party charger, the main interoperability barrier tends to be the connector. Therefore, the number of occasions in which consumers find themselves in this situation, and would benefit from this option (i.e. would not have otherwise had access to a compatible EPS), is likely to be very small.

d) **Confusion about which charger works with what**: Major positive impact. As already noted under point a) above, although the level of interoperability of EPS with different mobile phones is already high, consumers are not necessarily aware of this. Guaranteed interoperability in accordance with relevant standards could help reduce confusion in this respect significantly, especially if accompanying information measures were taken.

Option 5

If EPS for mobile phones were subject to interoperability as well as minimum power requirements, consumer convenience would be affected in the following main ways:

a) **Inability to charge certain devices (as fast) with certain chargers**: Major positive impact. In addition to the effects of option 4 (see above), this option would also ensure consumers are able to charge their phones with another charger at a similarly fast speed, and thereby largely eliminate one of the sources of inconvenience experienced by the highest number of consumers according to the survey (where 53% of respondents reported not being able to charge their phones *as fast* with another charger).

b) **Too many chargers:** No impact, for the same reasons discussed under the option 4 (see above and section 5.1).

c) **No access to a compatible charger**: Negligible / minor positive impact, for the same reasons as option 4 (see above).

d) **Confusion about which charger works with what**: Major positive impact, for the same reasons as option 4 (see above).

In summary, all five policy options would have a positive net effect on consumer convenience, but the significance of these, and the ways in which they affect different consumers in different circumstances, varies. These effects need to be seen against the backdrop of the relatively high rates of convergence and interoperability for both connectors and EPS expected under the baseline scenario (see section 4.1), which means the effects of the options on the convenience of the majority of consumers would be incremental rather than "game-changing".

Common connectors at the device end (option 1) would be most effective in terms of increasing the likelihood that consumers who are unable to access their own charger (e.g. because they are travelling) are able to find a compatible third-party charger, and would also enhance convenience by enabling users to charge all phones with the same cables. Similar benefits would arise if adaptors are allowed (options 2 and 3), but these benefits would be less pronounced overall, and could be partly outweighed by the inconvenience caused by having to use adaptors. Harmonisation of the EPS (options 4 and 5) would have major benefits in terms of ensuring consumers can charge different devices with their chargers, and reducing confusion in this respect. However, we expect it to only have a negligible (or minor at best) impact on consumers who require access to a compatible third-party charger. None of the options *per se* would lead to consumers having fewer chargers taking up space in their home and/or workplace; indirect effects on decoupling rates are possible but too uncertain to estimate with a sufficient degree of confidence (for further details see below).

Based on this, **options 1, 4 and 5 would all result in tangible benefits in terms of consumer convenience**. However, since these options would reinforce rather than revolutionise existing market trends (convergence towards USB Type-C connectors by nearly all manufacturers, already high degree of interoperability of EPS due to the proliferation of technology compatible with USB PD), they would not have major benefits across all consumer groups, but rather, eliminate or reduce residual inconvenience for certain users in certain situations. Overall, if we attach the same significance to each of the four main forms of consumer (in)convenience described above (as seems justified in view of the results of the consumer panel survey), the option that is likely to generate the most significant benefits to consumers is option 5, closely followed by option 4 and then option 1 (but the differences between them are relatively small). A combination of these options (i.e. simultaneously implementing option 1, as well as 4 or 5) would result in greater benefits by addressing more sources of inconvenience at once. On the other hand, **options 2 and 3 are likely to generate only very minor consumer convenience benefits overall**.

Decoupling

As noted above, the reduction of the inconvenience consumers experience due to having too many chargers depends on the decoupling rates that are achieved. If consumers had the choice to purchase phones without chargers (EPS and/or cables), those who prefer to re-use an existing charger with a new phone could do so, and as a result reduce the number of chargers taking up space in their homes and/or workplaces. This could also be expected to help reduce confusion about which charger works with what phone or other device.

In this context, it is worth reiterating that, as per the consumer panel survey, for the majority of consumers who prefer to buy a mobile phone bundled with a charger, the main reason is convenience (i.e. not having to worry about how to charge the phone). It could therefore be argued that decoupling would lead to increased (not reduced) consumer inconvenience. However, even the highest decoupling scenario (see section 5.1) assumes that the majority of new mobile phones would still be sold with a charger, as only those who prefer to re-use an existing charger would take advantage of the possibility of doing so.

As discussed previously, the extent to which the options contribute to voluntary decoupling is inherently difficult to estimate. However, we assume that the potential of the options that target the EPS (options 4 and 5) to encourage decoupling is higher than that of the options that focus on the device-end connectors (options 1, 2 and 3). Therefore, if decoupling on the scale we have estimated (see Table 22) were to occur, this slightly increases the consumer convenience benefits of all options (especially options 4 and 5), but does not affect their relative ranking.

Product safety

Charger safety is an important issue for consumers, public authorities, phone and charger manufacturers. As highlighted in section 3.9, unsafe and/or non-compliant charging devices account for a relatively large share of the alerts for electrical equipment which are registered by authorities on the EU RAPEX and ICSMS systems, with some evidence of an increasing trend in recent years. The issue primarily affects standalone charger sales, where outside of the quality assurance of phone manufacturers and other reputable OEMs, there are many products where compliance with safety and other standards is not guaranteed. Little known brands, unbranded and counterfeit products were the subject of most safety alerts. The growth of direct online purchasing of chargers has made it more difficult for market surveillance and public safety authorities to police the quality and safety of chargers that are entering the market. The majority of safety issues relate to the EPS component, with the most serious risks including fire and electrocution hazards for consumers, but also link to issues of device performance and failure which can impinge on consumer convenience. Manufacturers reported that one of the main reasons for them to provide chargers with their phones is to guarantee the quality, safety and performance of the devices, from both a consumer satisfaction and legal responsibility perspective (in the case of failure or safety issues).

None of the options as formulated for this impact assessment study (see chapter 4) directly address the issue of product safety; the new requirements they would introduce are intended to enhance the interoperability of chargers, not their safety. Nonetheless, it is worth considering if and how they might have indirect impacts on product safety. Based on the information at our disposal, there could be three main ways in which this could be the case:

- **Safety of stand-alone chargers**: As discussed previously, at present, safety risks and concerns relate almost exclusively to chargers that are sold separately (especially online). In principle, changes to the requirements for chargers could affects these in two main ways:
    - **Market size**: A priori, any intervention that leads to increased sales of stand-alone chargers appears likely to also lead to growth in the sub-standard, unsafe and/or counterfeit part of said market.
    - **Market characteristics**: Furthermore, it is worth considering whether any new requirements could make it easier or harder to produce and/or sell sub-standard stand-alone chargers.
- **Safety of in-the-box chargers**: In principle, the new requirements could also contribute to improving or reducing the safety of in-the-box (OEM) chargers, e.g. by making certain standards obligatory, and/or by reducing or increasing risks from using them to charge phones other than the one they were shipped with.

The second potential effect listed above (characteristics of the market for stand-alone chargers) has been considered but discarded from further analysis due to the lack of reliable evidence. A few stakeholders have argued that conformity around a single harmonised standard could make it easier for unscrupulous manufacturers to enter the market by using this single standard as a template for low quality products, thus increasing safety risks. On the other hand, it could also be argued that a single standard would make it easier (and potentially cheaper) to produce stand-alone chargers that conform to this standard, thereby reducing opportunities and/or incentives for manufacturers and distributors of sub-standard products. In the end, based on the information at our disposal, we see no strong reason to believe that any policy option that leads to a more widespread adoption of USB standards would make it inherently more or less difficult, or more or less attractive, to produce or distribute sub-standard stand-alone chargers. We conclude that any such effects, if they were to occur at all, would be negligibly small under all five of the options.

As regards the other two potential effects listed above, we consider the policy options would be likely to have the following effects:

Option 1

According to the consumer panel survey, users of phones with proprietary (i.e. Lightning) connectors purchase slightly more stand-alone chargers than users of phones with USB connectors. The elimination of proprietary connectors could be expected to eliminate this difference, thus leading to a small (about 3.4%) reduction in sales of stand-alone chargers (for further details of how the quantitative estimate was derived, see section 5.3 on environmental impacts) and, by extension, a similar reduction in the sub-standard market, leading to a small positive impact on overall product safety.

As regards the safety of in-the-box chargers, a common universal USB Type-C connector at the phone end would have no impact on product safety. Safety risks from in-the-box cables are negligible to begin with, and there is nothing to suggest this option would make any difference in this respect.

Option 2

The likely impacts on product safety would be identical to those of option 1, in terms of both the small effect on the stand-alone market, and the absence of any effects on the safety of in-the-box chargers. Furthermore, there is nothing to suggest that the proliferation of adaptors would result in additional safety risks, as these are small, simple components that, to the best of our knowledge, do not give rise to any significant product safety concerns.

Option 3

This option would have no impact on product safety. Unlike options 1 and 2, we do not expect option 3 to have any effect on the stand-alone market (since the connector on the in-the-box cable remains proprietary, Apple users would continue to purchase standalone chargers in the same volumes). Like options 1 and 2, it would also have no effect on the safety of in-the-box chargers.

Option 4

Regarding the market for stand-alone chargers, we assume the elimination of any residual incompatibility issues for EPS that would follow from this option to lead to a small (approx. 2.5%) reduction in standalone charger sales (for details of how this estimate was derived, see section 5.3 below). Like option 1, this would be likely to lead to a similar reduction in the sub-standard part of the market, leading to a very small positive impact on overall product safety.

As for the safety of in-the-box chargers, it seems reasonable to assume the universal adoption of harmonised standards (namely IEC 62680-1-3, IEC 62680-1-2 and IEC

63002) would reduce product safety risks when using these EPS to charge other phones and devices. However, the impact in practice is likely to be very small, since (as discussed previously) the degree of interoperability of different EPS with different phones is already high, and safety risks involving OEM EPS are minimal to begin with.

Option 5

In addition to eliminating any residual incompatibility issues for EPS, this option would mean all in-the-box EPS are fast-charging, thereby reducing the need for consumers who want better performance to buy a stand-alone charger. We assume that this would result in a reduction of around 5% in in standalone charger sales (for further details see section 5.3), a corresponding effect on the sales of sub-standard chargers, and hence, a small positive impact on product safety overall.

As regards the in-the-box chargers, increased power requirements can increase the severity and risk of electrocution and fire hazards if components are faulty or standards are not met. However, any such risks are likely to be cancelled out by the requirement for all EPS to comply with the standards referred to previously. Therefore, we do not expect the in-the-box EPS under this option to result in any increased safety risks.

In summary, the impact of all five policy options on product safety is expected to be very small compared to the baseline, as none of the options specifically addresses this issue. The only potentially significant indirect impacts are due to the expected reduction in overall stand-alone charger sales that follow from the enhanced interoperability of in-the-box chargers, and therefore the reduced need for consumers to purchase potentially unsafe stand-alone replacement or additional chargers. We conclude that options 1, 2, 4 and 5 would all be likely to have a small positive effect in this regard, which would be most significant under **option 5** (which would reduce sales of stand-alone chargers, and by extension also of sub-standard chargers, by approx. 5%). On the other hand, the safety risks from the use of OEM chargers that are shipped "in the box" with mobile phones are minimal to begin with, and we have identified no compelling reason to believe any of the options would make a material difference in this respect.

Table 24: Main effects of the policy options on product safety

	Connectors at the device end			**EPS**	
	Option 1	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Product safety impact	0/+ No impact on charger safety per se; small decrease in demand for potentially unsafe stand-alone chargers		0 No impact on charger safety per se, or on demand for potentially unsafe stand-alone chargers	0/+ Negligible impact on charger safety per se; small decrease in demand for potentially unsafe stand-alone chargers	0/+ No impact on charger safety per se; small decrease in demand for potentially unsafe stand-alone chargers

Decoupling

The potential effects of decoupling on product safety also need to be considered. As noted previously (see section 5.1), all options have the potential to contribute to increased voluntary decoupling, to a greater or lesser extent, but their actual effects are highly uncertain. Should decoupling rates increase (which appears most likely under options 4 and 5), consumers would no longer automatically receive a new, safe and compliant charger with their new phone. Instead, they would have the choice of using a charger they already own, or purchasing a new stand-alone charger. This could lead to an increase in the market for stand-alone chargers, which in turn would be expected to result in a proportional increase in the number of non-compliant and unsafe chargers entering the stock.

However, it is worth noting that, even under the most optimistic decoupling scenario, 60% of all new phones would still be sold with an EPS, and 80% would be sold with a cable. This is based on the assumption that those consumers who do not already own a functioning compatible would still choose to acquire one along with any new phone they purchase, and only those who are confident in their ability to use an existing charger that meets their charging needs and expectations would choose not to. Therefore, it does not necessarily follow that increased decoupling would go hand in hand with increased sales of (potentially unsafe) stand-alone chargers. It seems reasonable to assume that the majority of consumers who purchase a charger (EPS and/or cable) along with their new phone would still choose one from the same manufacturer. It also seems very likely that phone manufacturers would continue to offer their own (OEM) chargers separately, and may well dedicate more efforts to promoting these sales. A larger stand-alone market could also encourage more reputable manufacturers to enter, as well as encourage greater attention from product safety agencies.

Nevertheless, there remain concerns from stakeholders (including both industry representatives and national authorities) that, if chargers are no longer routinely included in the box with new phones, some consumers would resort to internet searches and purchase the cheapest, not necessarily safe or compliant, chargers they can find, and that it would remain difficult for authorities to monitor and police these sales, leading to increased product safety risks. These risks appear very minor under the lowest decoupling scenario (as decoupling would remain the exception, and only those consumers with a strong interest in reducing the number of chargers they own and/or their environmental footprint would seek out and take advantage of the option of purchasing a phone without a charger), but could be significant under the higher case scenario (in which decoupling would enter the "mainstream", and a desire to cut costs could play a significant role for potentially large numbers of consumers).

<u>Illicit markets</u>

As discussed previously (see section 3.8), an unknown but potentially significant part of the market for standalone chargers is currently counterfeit ("fake"). It is inherently difficult to anticipate how this segment of the market would evolve under the various harmonisation options being assessed, as the nature and extent of such criminal activity is impossible to predict. Nonetheless, it is worth exploring if and how the different options and scenarios could alter the opportunities and/or incentives for the import and sale of counterfeit chargers in the EU.

Device-end connectors (options 1, 2 and 3)

The options to prescribe a common connector at the phone end (with or without the possibility of providing adaptors to comply) as such appear unlikely to have a significant effect on the illicit market compared with the baseline scenario (for very similar reasons to those discussed above under product safety impacts). To reiterate, options 1 and 2 would be likely to result in a small reduction (approx. 3.4%) in the demand for stand-alone chargers, which, in principle, is expected to lead to a concomitant small decrease in the illicit market.

Beyond this, the elimination of proprietary connectors in favour of USB Type-C would obviously eliminate the market for cables with fake Lightning connectors (which some interviewed stakeholders argued is especially lucrative for criminals due to the relatively high retail prices Apple charges for its original accessories). However, there is no reason to expect this to lead to an overall reduction in the market for counterfeit cables (over and above that postulated above), or to expect that genuine cables with USB Type-C connectors offered by Apple and other manufacturers in future would be less expensive (and therefore offer fewer incentives to counterfeiters) than the range of cables that is currently available. On the other hand, it could also be argued that in a situation in which cables with USB Type-C connectors are increasingly ubiquitous, consumers would be more open to purchasing and using non-OEM cables (based on a greater awareness that cables from different brands are essentially "the same"), which would reduce the opportunities for counterfeiters (while potentially favouring cheaper non-branded products, as discussed in the previous section). However, this line of argumentation is highly speculative.

In summary, options 1 and 2 would be likely to result in a small decrease in the market for stand-alone chargers, and by extension, of counterfeit charging cables. Other than this, there is no clear evidence, and no unambiguous rationale, to suggest that options 1, 2 or 3 would be likely to have any significant positive or negative effects on the illicit market.

EPS (option 4 and 5)

As outlined in the section on product safety above (and discussed in greater detail in section 5.3 on environmental impacts below), options 4 and 5 are assumed to lead to a small decrease (of 2.5 and 5%, respectively) in the overall sales of stand-alone chargers. In turn, this is expected to result in a concomitant decrease in the illicit market.

Beyond this impact on the market as a whole, mandatory requirements for EPS included in the box with mobile phones or sold separately by phone manufacturers, appear unlikely to alter the market conditions for counterfeit chargers per se. On the one hand, minimum requirements that raise the bar for "standard" EPS, and therefore make them potentially more expensive, could be expected to increase demand for cheaper alternatives among consumers looking to purchase a stand-alone charger (e.g. because the one shipped with their phone was lost or damaged). However, the extent to which this demand would be met by counterfeit EPS, or by non-OEM / non-branded products, is impossible to predict. Greater awareness of the common standards could reduce the importance consumers attach to the charger's brand, and thus reduce the temptation to buy an apparently OEM (but actually fake) EPS, and cancel out some or all of the price incentive.

On balance, in the absence of conclusive evidence, we assume the effect of both options 4 and 5 on the market for counterfeit EPS to remain limited, i.e. mirror the trends in the stand-alone charger market as a whole.

In summary, options 1, 2, 4 and 5 are all expected to lead to a small decrease in demand for stand-alone chargers, and by extension also to a small decrease in the illicit market. However, there is nothing to suggest that any of the options would have a significant effect on the *share* of counterfeit products (cables and/or EPS) in the stand-alone charger market.

Table 25: Main effects of the policy options on the illicit market

	Connectors at the device end			EPS	
	Option 1	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Product safety impact	0/+ Small decrease in demand for stand-alone chargers incl. counterfeit ones; no other impacts on the illicit market		0 No impact on demand or other aspects of the illicit market	0/+ Small decrease in demand for stand-alone chargers incl. counterfeit ones; no other impacts on the illicit market	

Decoupling

For the reasons outlined above (see section on product safety), it does not necessarily follow that increased decoupling would go hand in hand with increased sales of (potentially counterfeit) stand-alone chargers. Nonetheless, a certain level of growth in the stand-alone market appears likely under the higher decoupling scenarios. There is an obvious risk that this would also increase the market for counterfeit chargers (even if we assume that their *share* of the market remains unchanged).

5.3 Environmental impacts

The key environmental impacts were introduced in section 3.6 of this report, which set out the modelled impacts of the baseline scenario in terms of raw material use, e-waste, recycling and CO_2 emissions. The stock model has also been used to model the impacts of each policy option for each of these environmental impact categories. This has required a number of assumptions to be made on how each option leads to different evolutions of the charger stock. The key differences in assumptions are set out in **Table 26** below. There are levels of uncertainty associated with each of these assumptions, these are explored further as part of the sensitivity checks presented in the methodological annex (Annex E).

Table 26: Summary of changes to the stock model compared to the baseline scenario

	Connectors at the device end			**EPS**	
Policy options for mobile phone chargers	1. USB Type-C only	2. USB Type-C only; for phones with proprietary receptacles, adaptors in the box compulsory	3. USB Type-C or proprietary; for cables with proprietary connectors, adaptors in the box compulsory	4. Guaranteed interoperability of EPS	5. Interopera-bility plus minimum power requirements for EPS
Changes in assump-tions compared to the baseline scenario	Assumes proprietary connectors are phased out in new phones from 2022, to zero by 2023, switching to USB C Reduction in standalone charger market based on difference in purchasing of standalone chargers between Apple and non-Apple users. Consumer survey shows Apple users 16% more likely to purchase standalone chargers. In this option standalone sales of proprietary charger share (21.4%) reduced by 16%, resulting in 3.4% fewer	Assumes proprietary connectors are phased out from 2022, to zero by 2023, switching to USB C Assumes that from 2023 an adaptor from USB C cable (device side) to proprietary is provided in same proportions to Apple market share (21.4%) Same impact on standalone market at option 1, resulting in 3.4% fewer standalone sales	Assumes that from 2023 adaptors from proprietary cable connectors to USB C (device side) are provided Assumes no impact on standalone market as Apple users will still purchase replacement proprietary chargers	No difference is modelled due to insufficient data on current standard compliance A reduction in standalone sales of 2.5% is assumed.[78] This reflects possible reduction in purchases of chargers to address incompatibility issues. Currently assumed to be very low, as >90% of EPS believed to be interoperable.	This option results in the 10% residual of non-fast chargers sold with phones in the baseline being reduced to zero by 2023. The reduction in standalone sales from option 4 of 2.5% is included. In addition a further 2.5% reduction is assumed as those that purchase a charger for faster charging no longer need to purchase an

[78] This assumption is made based on our experience in this work, from which we would estimate that incompatibility of the type this option addresses affects less than 10% of chargers. Common charging standards would address a large part of the incompatibility that exists, reducing the need for standalone charger purchases. But with a lack of supporting data on which this assumption rests, the 2.5% reduction in standalone charger sales should be treated cautiously. A similar effect could be foreseen for options 2 & 3 with the use of the adaptors.

	standalone charger sales overall.[77]				additional charger[79].

Based on these assumptions the policy options were modelled. The key results for environmental impacts are presented in summary below. Note: this does not include any potential effects from the decoupling scenarios; these are presented at the end of this section.

Table 27: Summary of environmental impact of policy options

Impact	Value	Baseline	Option 1	Option 2	Option 3	Option 4	Option 5
Material Use [tonnes]	Total 2023-2028	89,984	90,574	91,047	90,459	89 603	90 915
	Difference with baseline		590	1,064	476	-380	931
	Annual average	14,997	15,096	15,175	15,077	14 934	15 152
	Difference with baseline		98	177	79	-63	155
	As %		0.7%	1.2%	0.5%	-0.4%	1.0%
E-waste [tonnes]	Total 2023-2028	73 653	73 775	73 843	73 721	73 597	73 695
	Difference with baseline		122	190	68	-56	42
	Annual average	12 276	12 296	12 307	12 287	12 266	12 283
	Difference with baseline		20	32	11	-9	7
	As %		0.2%	0.3%	0.1%	-0.1%	0.1%
Of which Untreated [tonnes]	Total 2023-2028	13 585	13 607	13 618	13 597	13 575	13 591
	Difference with baseline		22	33	12	-10	6
	Annual average	2 264	2 268	2 270	2 266	2 263	2 265
	Difference with baseline		4	6	2	-2	1
	As %		0.2%	0.2%	0.1%	-0.1%	0.0%
Of which Treated [tonnes]	Total 2023-2028	31 529	31 564	31 597	31 563	31 505	31 553
	Difference with baseline		35	68	33	-24	24

[77] It is possible that indirectly this option would also provide benefits to non-Apple users by increasing the interoperability of the total pool of chargers available. Therefore if it became necessary to borrow a charger the likelihood that a compatible charger can be found would be higher. This could reduce the number of standalone chargers purchased. We did not have a sound basis to estimate this effect and therefore have not included it in the modelling of the option. If it was possible to quantify then this would improve the impact of the option. The sensitivity analysis in Annex E provides an indication of the magnitude of such an impact, with, all else being the same, environmental benefits scaling to around 80% of the reduction in chargers achieved, e.g. a 5% reduction in chargers leading to around 4% lower emissions and material use.

[79] In the consumer survey Q C2b 7.9% of consumers answered that they purchased a standalone charger to get fast-charging capabilities. As fast-charging is modelled to become the effective standard over the next 5 years, then the full 7.9% rate is assessed to not be a realistic assumption.

Impact	Value	Baseline	Option 1	Option 2	Option 3	Option 4	Option 5
	Annual average	5 255	5 261	5 266	5 260	5 251	5 259
	Difference with baseline		6	11	6	-4	4
	As %		0.1%	0.2%	0.1%	-0.1%	0.1%
CO_2 emissions [ktonnes]	Total 2023-2028	5 302	5 305	5 319	5 316	5 280	5 378
	Difference with baseline		3	17	14	-22	76
	Annual average	884	884	887	886	880	896
	Difference with baseline		0	3	2	-4	13
	As %		0.1%	0.3%	0.3%	-0.4%	1.4%

Raw material usage, e-waste and treatment for recycling

Raw material usage is influenced by the weight of the charger and its components. As the options influence the types of EPS and cables used in new chargers, they also influence the total raw material usage. As highlighted already in section 3.6, there is a trend towards heavier chargers as fast charging EPS technologies, which have more complex and heavier components gradually become the new standard. E-waste and waste treatment volumes are also strongly influenced by the weight of the charger and its components, but with a more significant lag until changes in charger type are reflected in volumes of waste, due to the time in which the charger is in use, or stored out of use prior to actual disposal. The policy options mainly influence differences in the cable connectors, and the addition of adaptors compared to the baseline. The other major effect is the modelled impact on standalone charger sales which in the case of options 1, 2, 4 and 5 results in a reduction in the total number of chargers purchased separately. Finally, it is also possible that the change to a new charger type may lead to more chargers becoming obsolete and disposed of to e-waste. This effect is expected to already naturally occur in the baseline scenario as the transition from USB Micro B to USB C gathers pace, although this will mostly have run its course by 2023, the year from which impacts are assessed. Given the difficulty to quantify such an effect we have not modelled it. If such an effect were present it would likely be strongest for the options leading to faster switches in charger types than in the baseline. The key differences can be summarised as follows.

Option 1

This option results in all chargers being supplied with cables ending in USB-C connectors at the device end. In practical terms this is modelled as a switch in the market share of cables with a USB C connector at the EPS end (as proprietary chargers are assumed to switch to EPS USB C by 2022 in the baseline) and a proprietary connector at the phone end (henceforth referred to as USB C – Proprietary), to cables with USB Type C connectors at both ends (USB C – USB C). The model assumes, based on reported and tested weights, that the USB C – USB C cables are slightly heavier than the proprietary cables.

This switch in charger types is also anticipated to have an impact on the standalone charger market. The rationale being that owners of Apple products no longer need to purchase proprietary replacement chargers and that their behaviour will more closely mirror that of other consumers. The consumer survey found that Apple users were 16% more likely to purchase a standalone charger than other users. Therefore, a reduction in standalone charger purchases of 3.4% was included (based on the 21.4%

Apple market share multiplied by the 16% lower frequency of standalone charger purchasing).

The balance of these two effects is slightly in favour of the former, i.e. the increase in weight and materials of the switch to USB C is not fully offset by the reduction in materials from reduced standalone charger sales. Overall, we assess that **this policy option leads to small increases in raw material usage, e-waste, untreated waste and treated waste volumes**:

- Raw material usage is 590 tonnes higher than the baseline total between 2023-2028, or around 98 tonnes per year. This represents a 0.7% increase compared to the baseline. The material usage broken down in the stock model showed that around 51% of the material usage is plastics, 6% copper and the remainder a mix of other materials. The split between the EPS and cable material volumes is 69% EPS to 31% cable.

- E-waste is 121 tonnes higher than the baseline total between 2023-2028, or around 20 tonnes per year. This represents a 0.2% increase compared to the baseline.

- Volumes of E-waste left untreated increase slightly to 22 tonnes higher than the baseline total between 2023-2028, or around 4 tonnes per year. This represents a 0.2% increase compared to the baseline.

- E-waste treatment volumes also increase slightly to 35 tonnes higher than the baseline total between 2023-2028, or around 6 tonnes per year. This represents a 0.1% increase compared to the baseline.

Option 2

This option is the same as option 1, but allows for manufacturers to provide adapters from USB C to proprietary connectors. This therefore results in additional material use not only from the switch to the slightly heavier USB C cables, but also from the addition of adaptors. As the adaptors are only estimated to be small (weighing around 2g), the additional material usage is also only small as a % of the baseline and compared to option 1.

The impacts on the standalone charger market are also evaluated in the same way as option 1.

Therefore we assess that **this policy option leads to a small increases in raw material usage, e-waste, untreated waste and treated waste volumes**:

- Raw material usage is 1,064 tonnes higher than the baseline total between 2023-2028, or around 177 tonnes per year. This represents a 1.2% increase compared to the baseline. The split between the component material volumes is almost the same as option 1 at 69% EPS, 30.5% to the cable and only 0.5% to the adaptors. The small volume from the adaptors means that there is no significant change to the material usage types noted in option 1.

- E-waste is 190 tonnes higher than the baseline total between 2023-2028, or around 32 tonnes per year. This represents a 0.3% increase compared to the baseline.

- Volumes of E-waste left untreated increase slightly to 33 tonnes higher than the baseline total between 2023-2028, or around 6 tonnes per year. This represents a 0.2% increase compared to the baseline.

- Waste treatment volumes also increase slightly to 68 tonnes higher than the baseline total between 2023-2028, or around 11 tonnes per year. This represents a 0.2% increase compared to the baseline.

Option 3

This option is a hybrid of the first two options, allowing for the continued sale of proprietary cables, but with mandatory provision of adaptors to USB C. This avoids the additional material use from heavier USB C cables but still requires the additional material use of an adaptor. The former effect is greater than the latter, as a result of the very low weight of adaptors, and as a result this policy option leads to a smaller increase in material usage than the first two options.

This option is assessed to have no impact on the standalone charger market. This is based on the fact that as the charger, and particularly the cable to device connector, remains proprietary, Apple users would continue to purchase standalone chargers in the same volumes. Whilst the adaptor would allow their charger to be used by non-Apple users, this is not expected to result in any material impact on the standalone market.

Compared to the baseline this option has only the additional impacts associated with the adaptors, which are very light, simple devices. We assess that **this policy option leads to small increases in raw material usage, e-waste, untreated waste and treated waste volumes**:

- Raw material usage is 476 tonnes higher than the baseline total between 2023-2028, or around 79 tonnes per year. This represents a 0.5% increase compared to the baseline. The split between the component material volumes is 69% EPS, 30.5% to the cable and only 0.5% to the adaptors. As a result there is no significant change to the material usage types as noted in option 1.

- E-waste is 68 tonnes higher than the baseline total between 2023-2028, or around 11 tonne per year. This represents a 0.1% increase compared to the baseline.

- Volumes of E-waste left untreated increase slightly to 12 tonnes higher than the baseline total between 2023-2028, or around 2 tonnes per year. This represents a 0.1% increase compared to the baseline.

- Waste treatment volumes also increase slightly by 33 tonnes higher than the baseline total between 2023-2028, or around 6 tonnes per year. This represents a 0.1% increase compared to the baseline.

Option 4

This option is difficult to assess, as the direct impact of the option is to affect protocols and standards of EPS, with minimal impact on the hardware itself. Changes in the latter are what drive environmental impacts to the largest extent.

Whilst there is no direct impact in this way, it is expected that the option does have an impact on the standalone charger market. By harmonising standards, it should significantly reduce any issues in incompatibility of EPS. Yet there is no strong data on the extent to which this is a problem. Whilst stakeholders and consumers identify incompatibility as a relevant issue, it is not understood to be a widespread problem and is not quantified. Based on our experience in this work, and given the lack of actual information, we would estimate that incompatibility affects less than 10% of chargers. To estimate the impact of common charging standards we assume a 2.5%

reduction in standalone charger sales, but it should be kept in mind that this assumption is an expert judgement with limited supporting data.

Compared to the baseline, the only tangible difference of this option is the reduction in standalone sales, therefore we assess that **this policy option leads to small reductions in raw material usage, e-waste, untreated waste and treated waste volumes**:

- Raw material usage is 380 tonnes lower than the baseline total between 2023-2028, or around 63 tonnes per year. This represents a 0.4% decrease compared to the baseline. The split between the component material volumes is 69% EPS and 31% to the cable.
- E-waste is assessed to be 56 tonnes lower than the baseline total between 2023-2028, or 9 tonnes per year. This represents a 0.1% decrease compared to the baseline.
- Volumes of E-waste left untreated decrease and are 10 tonnes lower than the baseline total between 2023-2028, or around 2 tonnes per year. This represents a 0.1% decrease compared to the baseline.
- Waste treatment volumes also decrease slightly, being 24 tonnes lower than the baseline total between 2023-2028, or around 4 tonnes per year. This represents a 0.1% decrease compared to the baseline.

Option 5

This option builds on option 4, applying both the harmonised standards, but also requiring a minimum power output consistent with current fast charging technology. This second requirement does have a material impact upon the chargers supplied with phones, as the baseline assumes a tail of 10% of phones that continue to be sold with 'standard' (non-fast charging) chargers. Whilst the baseline has a tail of standard EPS USB A until 2024, and a standard EPS USB C from 2020 and constituting the 10% residual by 2025, option 5 models a decline in both these types from 2022, reducing their market share to 0% in 2023 as the requirements introduced by this option take effect. The enforced change to fast chargers naturally results in heavier, more environmentally impactful chargers than in the baseline.

Additional to the direct impact on chargers provided with new phones is the indirect impact on the standalone charger market. The consumer survey noted that 7.9% of consumers purchased standalone chargers to get a fast charger, giving an indication of the demand. Yet in the baseline, by 2023 fast chargers already account for 90% of chargers provided with new phones and therefore the potential demand is likely to be much smaller. In our opinion the effect is likely similar to that of option 4, therefore we assume an additional 2.5% reduction in standalone charger sales due to option 5, resulting in a 5% overall reduction in standalone charger sales (as it builds on option 4). Again it should be kept in mind that this assumption is an expert judgement with limited supporting data.

The first effect is more significant than the second, affecting many more chargers, therefore this option is assessed to **lead to small increases in raw material usage, e-waste, untreated waste and treated waste volumes.** :

- Raw material usage is 931 tonnes higher than the baseline total between 2023-2028, or around 155 tonnes per year. This represents a 1.0% increase compared to the baseline. The split between the component material volumes is 70% EPS and 30% to the cable.

- E-waste is assessed to be 42 tonnes higher than the baseline total between 2023-2028, or 7 tonnes per year. This represents a 0.1% increase compared to the baseline. The two effects, increased weight of chargers and reduced standalone sales, are approximately in balance in this time frame. In future, as heavier fast chargers become waste, we would expect a small increase in e-waste volumes.

- Volumes of E-waste left untreated increase very slightly to 6 tonnes higher than the baseline total between 2023-2028, or around 1 tonnes per year. This represents a 0.04% increase compared to the baseline.

- Waste treatment volumes also increase, being 24 tonnes higher than the baseline total between 2023-2028, or around 4 tonnes per year. This represents a 0.1% increase compared to the baseline.

In summary, **across all options, the changes in material consumption, e-waste, untreated waste and treated waste , at less than 2.1%, are very low under every option**. Option 4 is the only option which provides positive environmental impacts, through reducing standalone sales. Options 1, 2 and 5 are also expected to reduce standalone charger sales, which mitigates the increased environmental impact from the main measures the option introduces. Option 1 has a negligible negative environmental impact, whilst options 2, 3 and 5 have more significant, but still small, negative impacts.

CO_2 emissions

The GHG emissions impacts of chargers are a factor of both the weight and content of the different components of a charger. The key assumptions for these were presented in section 3.6, where profiles for component types were develop which provide emissions multipliers per g of weight for EPS, cables and adaptors. Combining these with the stock model assumptions, we have assessed the emissions impacts of the different options. These represent the full life-cycle emissions of the chargers sold each year under each option. The split of emissions between components remains quite constant across the options, with around 84% of the emissions attributable to the EPS and 16% to the cable. For the options using adapters the share of total emissions remains below 0.5%.

Option 1

The increased weight of USB C – USB C cables (compared to USB C – Proprietary cables) means that there are higher emissions associated with these cables resulting from emissions embedded in the materials used and the transportation of the finished charger to market. The reduction in standalone sales, explained in the previous section, has an offsetting effect, reducing the emissions associated with chargers as a whole, including heavier EPS components which are also more emissions intensive over their full lifecycle. Yet the effect is not quite enough to result in net emissions reductions savings. We assess that the balance of these two impacts results in GHG emissions of this policy option of 3 $ktCO_2e$ higher than the baseline total between 2023-2028, or less than 1 $ktCO_2e$ per year. This represents a 0.1% increase compared to the baseline. For context the baseline emissions annual average of 884 $ktCO_2e$ per year represents around 0.02% of EU28 total 2017 emissions of 4 483 100 $ktCO_2e$. The emissions impacts are very small and particularly the differences compared to baseline.

Option 2

This option is identical to option 1, but with the addition of adaptors, although small, they do lead to additional associated emissions, leading to higher emissions compared to option 1. . We assess that the GHG emissions of this policy option are 17 ktCO_2e higher than the baseline total between 2023-2028, or around 3 ktCO_2e per year. This represents a 0.3% increase compared to the baseline.

Option 3

The addition of adaptors compared to the baseline means that option 3 has higher emissions than the baseline. We assess that the GHG emissions of this policy option are 14 ktCO_2e higher than the baseline total between 2023-2028, or around 2 ktCO_2e per year. This represents a 0.3% increase compared to the baseline.

Option 4

As explained above, the only tangible impact of option 4 is the reduction in standalone sales, this results in lower impacts. We assess that the GHG emissions of this policy option are 22 ktCO_2e lower than the baseline total between 2023-2028, or around 4 ktCO_2e per year. This represents a 0.4% reduction compared to the baseline.

Option 5

Option 5, whilst including a higher reduction in standalone sales than option 4, sees an increase in impact as the greater weight and emissions intensity of the EPS used in fast chargers means this is the dominant of the two effects. We assess that the GHG emissions of this policy option are 76 ktCO_2e higher than the baseline total between 2023-2028, or around 13 ktCO_2e per year. This represents a 1.4% increase compared to the baseline.

In summary, **only one of the options (option 4) is assessed to lead to a small reduction in GHG emissions, whilst options 1, 2 and 3 are assessed to lead to small increases in emissions.**. Option 4 is assessed as the most positive of the options, reducing emissions by 0.4%. Whilst options 1, 2 and 3 are expected to lead to small emissions increases of 0.1-0.3%. Option 3 has small negative impacts associated with the additional adaptors, whilst option 5 is most negative of all. The clearest indication from this is that changes in the number or type of EPS have the greatest impact on emissions, and that mandating fast charging as per option 5 will be likely to result in higher emissions.

Decoupling scenarios

As noted above, the environmental impacts of the proposed policy options are limited, namely because although they lead to small changes in the *types* of charges supplied to consumers, the total *number* of chargers remains quite similar, with only small impacts on standalone charger sales anticipated as resulting from the options. Supplying phones without a charger – decoupling the charger from the phone – is one way in which significant environmental impacts could be foreseen. Although outside the scope of our main policy options, we have also used the stock model to model the impact of the three decoupling scenarios – as applied to the baseline – that were introduced in section 5.1. These provide an indication of the potentially significant environmental benefits that decoupling could bring.

The results are shown in Table 28 below, these show significant impacts:

- Raw material use between 4-32% lower than in the baseline scenario, resulting in annual raw material savings of 610-4,860 tonnes.

- E-waste generation between 2.5-15.4% lower than in the baseline scenario, resulting in annual volume reductions of 310-1,890 tonnes.
- Untreated waste volumes decreasing by 2-15% compared to the baseline scenario, resulting in annual volume reductions of 55-335 tonnes.
- Waste treatment volumes decreasing by 3-16% compared to the baseline scenario, resulting in annual volume reductions of 140-820 tonnes.
- GHG emissions between 4-33% lower than in the baseline scenario, resulting in annual emissions reductions of 36-292 ktCO_2e.

Table 28: Summary of environmental impact of decoupling scenarios

Impact	Value	Baseline	Lower case scenario	Medium case scenario	High case scenario
	Peak decoupling % (EPS)	0%	5%	15%	40%
Material Use [tonnes]	Total 2023-2028	89 984	86 344	79 037	60 836
	Difference with baseline		-3 640	-10 947	-29 148
	Annual average	14 997	14 391	13 173	10 139
	Difference with baseline		-607	-1 824	-4 858
	As %		-4.0%	-12.2%	-32.4%
E-waste [tonnes]	Total 2023-2028	73 653	71 812	68 652	62 458
	Difference with baseline		-1 841	-5 001	-11 196
	Annual average	12 276	11 969	11 442	10 410
	Difference with baseline		-307	-834	-1 866
	As %		-2.5%	-6.8%	-15.2%
Of which Untreated [tonnes]	Total 2023-2028	13 585	13 258	12 698	11 601
	Difference with baseline		-326	-887	-1 984
	Annual average	2 264	2 210	2 116	1 934
	Difference with baseline		-54	-148	-331
	As %		-2.4%	-6.5%	-14.6%
Of which Treated [tonnes]	Total 2023-2028	31 529	30 733	29 365	26 687
	Difference with baseline		-797	-2 164	-4 842
	Annual average	5 255	5 122	4 894	4 448
	Difference with baseline		-133	-361	-807
	As %		-2.5%	-6.9%	-15.4%
CO_2 emissions [ktonnes]	Total 2023-2028	5 302	5 083	4 644	3 550
	Difference with baseline		-219	-658	-1 752
	Annual average	884	847	774	592
	Difference with baseline		-36	-110	-292
	As %		-4.1%	-12.4%	-33.1%

The contrast of the significant results under the higher decoupling scenarios, with the very limited impacts of the policy options, highlights the fact that the initiative as currently conceived could only be expected to have significant environmental benefits if the harmonisation of charger components led to greater decoupling. As discussed previously (see section 5.1), the extent to which this would happen on a voluntary basis is highly uncertain, but the potential appears highest under options 4 and 5, especially if combined with option 1.

5.4 Economic impacts

This section assesses the economic impacts for key stakeholders, including industry, consumers and public authorities, under each policy option. These include an estimation of the financial costs for the main affected groups, and of the potential impacts on innovation. Where possible, costs and benefits are quantified in monetary terms. In other cases, a qualitative assessment is provided.

Quantitative estimations are based on the stock model developed for this study, and the results presented in what follows represent the difference in impact between the policy option being assessed and the baseline. The differences observed relate mainly to the differences in quantities of mobile phone chargers sold in the EU under each option (both standalone chargers and chargers included in the box). For further detail on the calculations and assumptions made under each policy option, see Annex E.

The identification of economic impacts follows the categories listed in Tool #19 of the Better Regulation Toolbox. An assessment of their relevance is provided below.

Table 29: Types of economic impacts considered

Economic impact	**Assessment**	**Relevance**
Operating costs and conduct of business	The policy options affect not only new mobile phone models, but all mobile phones sold in the EU market from 2023 onwards, including old models. Therefore, it is expected that manufacturers producing / providing proprietary charging solutions in the box will need to adapt their production lines and/or packaging to standard solutions to comply with the new requirements.	High
Administrative burdens on businesses	The administrative burden of the initiative will depend on the option chosen by the industry (or requested by the authorities) to demonstrate compliance, i.e. whether businesses claim they are compliant, or whether they decide to go through a certification process. If the latter, the administrative burden (and costs associated) could be significant.	Medium
Trade and investment flows	The initiative may give rise to non-tariff barriers (manufacturers could not sell mobile phones using proprietary charging solutions) and it may also affect regulatory convergence with third countries (e.g. if a third country regulates for the use of different charging technologies). However, all policy options are based on international standards, meaning these impacts (if any) are expected to remain limited.	Low
Competitiveness of businesses	This initiative may affect competitiveness in several ways: • The policy options require the use of certain EPS and/or connectors that have a higher cost than other charging solutions (e.g. EPS and connector using USB C are more expensive than those using USB micro-B and/or USB A). • Some proprietary connectors are compatible only with certain accessories (cables, docking stations, speakers…), which may affect businesses' market share and their competitive position. This would affect phone manufacturers and their suppliers. • Manufacturers of proprietary solutions may lose the income generated by royalties.	High
Position of SMEs	Most economic operators in the sector are big companies located in third countries. However, there are some SMEs in Europe that might be affected:	Low / negligible

Economic impact	Assessment	Relevance
	• Companies that supply/distribute charging solutions to phone manufacturers: The profile of these companies, overall, is designers (not manufacturers) of tailor-made charging solutions, and distributors. In interviews, these companies clarified that the initiative would only affect them if the initiative is strict and imposes very specific charging characteristics (current and voltage). According to interviewees, this would eliminate the added value that they provide in the design of the chargers, which are tailor-made for the batteries they are meant to charge, and would very negatively affect their businesses. However, none of the policy options incorporates such specific requirements. • Phone manufacturers in the EU: There are a few small mobile phone manufacturers that are based in the EU. The one SME interviewed welcomed the standardisation of charging solutions, as it would create a level playing field for companies. The interviewee considered that there would not be any negative economic impacts if there is a period of implementation that fits with normal product cycles (this cost is analysed under *Operating costs and conduct of business*).	
Functioning of the internal market and competition	The initiative would not impact the free movement of goods, services, capital or workers.	Negligible
	The initiative would affect consumer choice, in case consumers value the fragmentation in charging solutions. This impact is covered in section 5.2 (social impacts).	N/A
Innovation and research	The initiative may affect innovation in charging technologies that are not compliant with the policy options (e.g. innovation in new connectors or fast charging technologies). The significance of this impact will depend on the chosen policy instrument, with higher negative impacts if the instrument is a regulation (as opposed to a voluntary agreement). This is because under a voluntary agreement, manufacturers would not be deterred from investing in innovation, as new products could still be introduced in the EU market and might produce a competitive advantage for the innovative company.	Medium
Public authorities	Costs to public authorities may arise in two ways: • Cost of adapting the standard to the requirements of the EU regulation. This cost is expected to be low / negligible, as existing standards would be used for any policy option. • Increase in control costs for surveillance authorities to check an additional standard. Given that control and surveillance systems are already in place, the marginal cost for testing any additional requirement is expected to be very low or negligible in all policy options.	Low / negligible
Consumers and households	This initiative has the potential to affect consumers in two main ways: • The initiative would affect the prices of the products under all policy options, as explained above, and this cost is expected to be passed on to consumers. • Manufacturers might decide not to sell (some of) their products in the EU as a consequence of the regulation, which would affect consumers' ability to access certain goods. For example, under Option 1,	High

Economic impact	Assessment	Relevance
	Apple might decide not to sell phones in the EU to avoid the shift from Lightning to USB C connector. However, in view of the size of the EU market, the likelihood of this seems very low.	
Specific regions or sectors	In light of the fact that the vast majority of economic operators that would be affected are not based in the EU, this initiative is unlikely to affect specific sectors or regions in the EU.	Negligible
Third countries and international relations	This initiative is not expected to have effects on trade agreements or international relations (see also the comment on trade and investment flows above).	Negligible
Macroeconomic environment	The initiative is not expected to have effects on economic growth, employment or other macroeconomic figures in the EU.	Negligible

Our assessment of economic impacts per policy option focuses on those economic impacts that have been assessed as being of medium or high relevance. This includes:

- Operating costs and conduct of business
- Administrative burdens on businesses
- Competitiveness of businesses
- Costs for consumers
- Innovation and research

A summary of the assessment of economic impacts is provided in **Table 30**. These impacts are described in detail in the remainder of this section.

Table 30: Assessment of economic impacts per policy option

	Connectors at the device end			EPS	
Type of cost and affected stakeholders	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Operating costs and conduct of business – mobile phone manufacturers (ROW, but a minority in EU)	- Manufacturers using proprietary solutions will need to change the design of their phones, including current models	-/0 Manufacturers using proprietary solutions will need to change their cables in the box to USB C. Minimal cost.	0 Adaptors USB C to proprietary are already available in the market. Cost of packaging changes are negligible	0 Changes in comparison with baseline are negligible	-/0 Cost of adaptation for manufacturers of lower end mobile phone chargers
Administrative burdens on businesses – mobile phone and EPS manufacturers (ROW, a minority in EU)	0 These policy options, in principle, are not associated with standards			- Cost of conformity assessment (demonstrating compliance with standards) may be moderate, but depends largely on the legal instrument chosen by the EC	

	Connectors at the device end			EPS	
Type of cost and affected stakeholders	**Option 1**	**Option 2**	**Option 3**	**Option 4**	**Option 5**
Competitive-ness of businesses – phone and EPS manufacturers and their supply chain (ROW, a minority in EU)*	- -655 million Euros (decrease in revenue for the industry) Loss of competitive advantage of Apple supply chain	0 -20 million Euros (decrease in revenue for the industry)	+ 658 million Euros (increase in revenue for the industry)	-/0 -77 million Euros (decrease in revenue for the industry)	0/+ 201 million Euros (increase in revenue for the industry)
Costs for **consumers** (EU)*	+ Savings: 680 million Euros (cost 6.4% lower than in baseline)	-/0 Costs: 50 million Euros (cost 0.5% higher than in baseline)	- Costs: 753 million Euros (cost 7.1% higher than in baseline)	0/+ Savings: 95 million Euros (cost 0.9% lower than in baseline)	- Costs: 452 million Euros (cost 4.3% higher than in baseline)
Innovation and research (ROW)	- Minor negative impact on R&D investment on new connectors	0	0	- Minor negative impact on innovation for fast charging technologies that are not compatible with USB PD	- Minor negative impact on innovation for fast charging technologies that are not compatible with USB PD

** Values expressed in Net Present Value for the period 2023-2028, using 2020 as base year, and a discount rate of 4% per year, as per the Better Regulation Toolbox (Tool #61)*
ROW = Rest of the world

Operating costs and conduct of business

The introduction of new requirements for the connectors and/or the EPS would affect all manufacturers of mobile phones, as it would apply to current models as well as new models. However, it would have a more significant effect on those manufacturers who plan to transition at a slower pace to the new requirements, or those who have proprietary solutions and do not currently plan to transition to new requirements at all. We have hypothesised that these costs are borne by the industry and not passed on to consumers, at least in the short term, given its impact on firms' competitiveness. This assumption is based on the qualitative information gathered in this study (views provided by interviewees).

Option 1

Option 1 assumes all phones placed on the market from the entry into force of the new requirement, both new and old models, will need to incorporate USB C connectors. For all manufacturers of mobile phones, this would imply the need to redesign **old models** (which would add costs) or remove these devices from the market, which would result in foregone income to manufacturers. However, given the timescales foreseen in our policy options, with start date in 2023, the impact is expected to be negligible for phone manufacturers that do not use proprietary solutions (since we predict that, in the baseline scenario, no phones with USB micro-B connectors will be sold beyond 2022).

This option would also have impacts on **new models**, mainly for manufacturers who do not plan to transition to USB C at all (i.e. those **using proprietary connectors**). These manufacturers would need to adapt their production line to include USB C. This cost is expected to be **significant,** as it would affect 21% of mobile phones sold in 2023. It should be noted that these manufacturers are not located in the EU.

Finally, this would also have an effect on the supply chain, particularly businesses producing cables and/or accessories with Lightning connectors. The impact in these cases is expected to be minor, due to the following considerations:

- Businesses producing cables with Lightning connectors normally also supply cables with USB connectors. Therefore, the operating cost is expected to be low (although this option could affect the competitiveness of such businesses, which is assessed below).
- There are relatively few new accessories being produced with Lightning connectors due to the increase use of wireless connection via Bluetooth (e.g. new speakers and headphones incorporate wireless connectivity, and newer iPhone models do not support wired connections), which limits the extent to which suppliers of accessories would be affected.

Options 2 and 3

These options allow the use of adaptors, and therefore makes possible the continued use of proprietary or USB micro-B connectors in the device. Therefore, under these options the adaptation costs would be minimal, and would be limited to the cost of including adaptors in the box, which is considered to be a very minor impact.

Under option 2, in addition, the cables included in the box will need to be USB-C, which would entail a cost for those manufacturers that currently include proprietary connectors. It is assumed that mobile phone manufacturers using proprietary solutions would need to add/change current suppliers who could provide USB-C cables, which might imply a minor cost.

Options 4 and 5

Option 4 obliges mobile phone manufacturers to include EPS in the box that are compliant with interoperability standards. The adaptation cost for mobile phone manufacturers, in this case, would be negligible, as it does not differ substantially from the baseline situation. Phone manufacturers have their own processes to ensure the EPS they sell are safe and compatible with the device, and hence assessing compliance with interoperability standards would not represent a significant increase in the marginal cost of the mobile phone.

Option 5 adds the obligation to include EPS that supply, as a minimum, 15W. However, interoperability standards ensure that the EPS is compatible with phones that require less power. Therefore, no impact on phone manufacturers is expected from this option either.

These options, nonetheless, would have operating costs for manufacturers of mobile phone chargers if they need to start producing EPS with interoperability standards and/or fast charging technologies (USB PD) at a faster pace than they would do normally, if at all. We estimate that this might affect a small proportion of EPS under Option 4, potentially smaller than 10% as we confirmed during interviews with phone manufacturers that they are converging towards the use of interoperability standards anyway. As regards option 5, our model assumes that this would affect at least 10% of the EPS sold in 2023 (including EPS sold in the box and standalone sales).

We estimate that the impact of option 4 on operating costs would be negligible, whereas option 5 would have a minor impact on manufacturers of mobile phone chargers.

Administrative burdens on businesses

The administrative burden of the initiative refers to the costs of demonstrating compliance with the standard or regulation in question (conformity assessment). The costs vary substantially depending on the type of regulation (e.g. essential requirement, harmonised standard…) and on the option given to / chosen by manufacturers to demonstrate compliance (e.g. presumption of conformity, or other methods).[80]

This cost might be applicable to all policy options. Options 1, 2 and 3 would mandate for the use of USB Type C connectors; however, we assume that compliance with the pertinent USB Type C standards would not have to be formally demonstrated or certified, as the shape of the connectors is obvious to the naked eye. On the other hand, policy options 4 and 5 make explicit reference to IEC standards, and therefore we assume that the probability that the EC would use harmonised standards or similar instruments to ensure compliance of these options is greater.

The Commission has advised that, in case of intervention (either voluntary or regulatory), compliance would need to be demonstrated via a conformity assessment, and that companies could choose to do this through either self-declaration or third party testing. We assume, therefore, that Options 4 and 5 may have a moderate impact on administrative burdens on businesses.

Competitiveness of businesses

This type of cost encompasses three different effects:

a) Revenues or costs generated from the production and sale of chargers that have different characteristics than in the baseline scenario

b) Changes to the distribution of revenue among the supply chain

c) Loss of income from royalties

The first effect can be estimated with our stock model, whereas the other two can only be assessed qualitatively.

We have estimated the **gross profit generated via the sale of chargers** (both in the box and stand-alone) for each policy option, and we have compared it to the gross profit in the baseline, using the following formula:

$$GPPO_j = \sum(Pi \times Qi) + \sum(SPi \times SQi) - \sum(Ci \times Qi) - \sum(Ci \times SQi)$$

Where:

- $GPPO_j$ = Gross profit for manufacturers in Policy Option j

[80] More information on conformity assessment is available at: https://ec.europa.eu/growth/single-market/goods/building-blocks/conformity-assessment_en

- P_i = Price of type of charger i when sold in the box
- Q_i = Quantity of type of charger i sold in the box
- SP_i = Price of type of charger i when sold as a standalone charger
- SQ_i = Quantity of standalone chargers sold of type i
- C_i = Production cost of manufacturing a charger of type i

The quantities of each type of charger are derived from our stock model, whereas the costs and prices are assumed to be the following:

Table 31: Assumed costs and prices of chargers

Product	Type of product	Production cost (€)	Price when sold in the box (€)	Stand-alone price (€)
EPS - USB A	USB A - Standard charger	1.2	1.5	6
	USB A - Fast charger - USB-PD	2.3	4	10
	USB A - Fast charger - proprietary	3	3.5	9
EPS - USB C	USB C - Standard charger	2.5	6	11
	USB C - Fast charger - USB-PD	4	8	15
	USB C - Fast charger - proprietary	4	8	15
Cables (1m)	USB A - USB Micro B	0.4	0.5	2
	USB A - USB C	0.75	0.9	3
	USB A - proprietary	0.6	0.7	25
	USB C - USB C	1.2	1.5	8
	USB C - proprietary	1.2	1.7	25
Adapter	Adapter USB Micro B - USB C	0.5	0.5	7
	Adapter Proprietary - USB Micro B	0.5	0.5	25
	Adapter Proprietary - USB C	0.5	0.5	25

Source: own estimations based on information provided by interviewees and prices quoted on various online retail and wholesale websites.

Comparing the net present value (NPV) of the gross profit obtained by the industry across the different policy options with the baseline, we observe the following:

Table 32: Difference in gross profit for the industry per policy option (Million Euro)

	Baseline	Option 1	Option 2	Option 3	Option 4	Option 5
Total 2023-2028	6,184	5,529	6,164	6,842	6,107	6,385
Difference with baseline		-655	-20	658	-77	201
Annual average	1,031	922	1,027	1,140	1,018	1,064
Difference with baseline		-109	-3	110	-13	33
As %		-10.6%	-0.3%	10.6%	-1.2%	3.2%

The impact of options 2 and 4 is very minor (around 1% of variation in gross profit). However, under option 1 we estimate a decrease in gross profit for the industry of almost 11% from the sale of chargers, as compared to the baseline. This is due to the shift in sales of chargers using Lightning connectors to USB C, and the fact that this reduces the margins obtained by the industry per charger sold.[81]

In option 3, Lightning connectors could still be used in the devices if an adaptor is included in the box. The inclusion of the adaptors is what increases the revenues for manufacturers. Option 2 also mandates for the inclusion of connectors, but this effect is more than offset by the shift in cables from Lightning to USB C. Option 5, by requiring more expensive fast chargers as standard, results in increased gross profit for manufacturers which more than offset declining income from standalone sales.

The second effect to be analysed is the potential **shift of the distribution of revenue among the supply chain**. This effect is due to some proprietary connectors being compatible only with certain accessories, including cables or adaptors. Currently, manufacturers supplying these accessories have a competitive advantage over other suppliers as they have gone through a process to become Apple suppliers and have adapted their production lines to Lightning connectors. This process generated a cost, and therefore these companies' position in the market may be disadvantaged if they lose their competitive advantage or do not obtain as many revenues as expected from the sale of accessories compatible with Lightning. This effect is expected to be significant in Option 1, with no effect in other options.

Last, some policy options may also generate a **loss of income from royalties** for those who own proprietary charging solutions and that receive royalties from the licencing of such solutions. Under policy option 1, this would affect Apple's income from royalties of selling third-party devices and accessories using the Lightning connector. Options 2 and 3 would not have any impact on income from royalties since proprietary connectors would still be allowed. Options 4 and 5 also mandate the use of interoperability standards, but this does not exclude that EPS may also incorporate proprietary solutions. Indeed, most EPS currently available on the market are interoperable with both USB PD and Quick Charge. Hence, only option 1 would result in loss of income from royalties. This would imply a loss of revenue for Apple, and this effect may go beyond chargers (cables), as it would also affect other accessories

It should be noted that our stock model is subject to the following **limitations**:

- Actual production costs and prices are valuable information and can vary considerably by supplier and brand. We have used the best information

[81] The margin for the industry of selling USB C to USB C cables is 0.3€ when sold in the box, and 6.8 € when sold as standalone cables; these margins increase to 0.5€ and 23.8€, respectively, for USB C to Lightning cables.

available, but uncertainties remain. The calculated values based on these figures should be considered with caution.

- Production costs for the different charging solutions (EPS and cables) have been kept constant over time. While this is a reasonable assumption, given the uncertain evolution of prices, it may overestimate the costs of new solutions (such as USB Type-C connectors), as these are expected to reduce over time.

- Costs or savings for distributors are not included, as these are not expected to be significant for charging solutions included in the box.

- There are other industrial sectors that are not included in our framework, such as chip manufacturers, who may experience loss of income under certain policy options. However, we believe the effects derived from the policy options are not significant (e.g. sales of EPS using proprietary solutions might decrease in Options 4 and 5, but most EPS with proprietary solutions, such as Quick Charge, are already interoperable with USB standards).

- Our model only quantifies net effects, whereas redistribution of sales/income among different industry stakeholders is assessed qualitatively.

Costs for consumers

The price that consumers will pay for their chargers, whether included in the box or bought separately, will be affected by the policy options, in the same way that the options affect the gross profit that manufacturers receive. The formula to calculate the cost for consumers is as follows:

$$\text{CPO}_j = \sum(Pi \times Qi) + \sum(SPi \times SQi)$$

Where:

- CPO_j = Cost for consumers in Policy Option j
- P_i = Price of type of charger i when sold in the box
- Q_i = Quantity of type of charger i sold in the box
- SP_i = Price of type of charger i when sold as a standalone charger
- SQ_i = Quantity of standalone chargers sold of type i

More details on the assumptions made on units of chargers sold per policy option and prices of chargers is included in Annex E.

Table 33: Difference in cost for consumers under each policy option (Million Euro)

	Baseline	Option 1	Option 2	Option 3	Option 4	Option 5
Total 2023-2028	10,632	9,952	10,682	11,385	10,537	11,085
Difference with baseline		-680	50	753	-95	452
Annual average	1,772	1,659	1,780	1,898	1,756	1,847
Difference with baseline		-113	8	125	-16	75
As %		-6.4%	0.5%	7.1%	-0.9%	4.3%

As expected, the options that are more favourable to the industry, are less favourable for consumers, and *vice versa*. In this case, Option 3 would increase the cost that consumers have to pay for their chargers, due to the inclusion of adaptors in the box.

Option 1 would be the best option for consumers since the shift from Lightning connectors to USB C is expected to reduce the price that consumers have to pay for their chargers, especially when these are sold separately (stand-alone sales). Under options 4 consumer costs are lower due to reduced standalone sales. For option 5, the higher price of the chargers (fast chargers are more expensive than standard chargers) more than offsets the lower sales of standalone chargers compared to the baseline.

In addition to these variable costs which depend on the quantity and type of chargers sold, manufacturers could pass on to consumers the fixed costs of the intervention (e.g. operating costs and administrative burden). We have hypothesised that these costs will be borne by the industry and not be passed on to consumers, as that would affect firms' competitiveness (particularly operating costs as they do not affect the whole market). That notwithstanding, a small fraction of these costs might be passed on to consumers.

Innovation

One of the main concerns related to harmonising mobile phone chargers, highlighted by the industry and some consumers, is the potential impact on innovation. As explained in Section 3.7, an obligatory regulation (vs. a voluntary approach) may decrease investment flows towards R&D projects to develop new charging solutions.

Literature review

As Blind, Petersen, Riillo (2017) highlight[82], the impact of regulatory instruments on innovation has been discussed with great controversy in academic literature. On the one hand, complying with regulations is likely to increase costs or restricts firms' freedom of action (Palmer et al., 1995)[83]. On the other hand, well designed regulation may guide or even force firms to invest in innovative activities, implement innovative processes or release innovative products (Porter and van der Linde, 1995)[84].

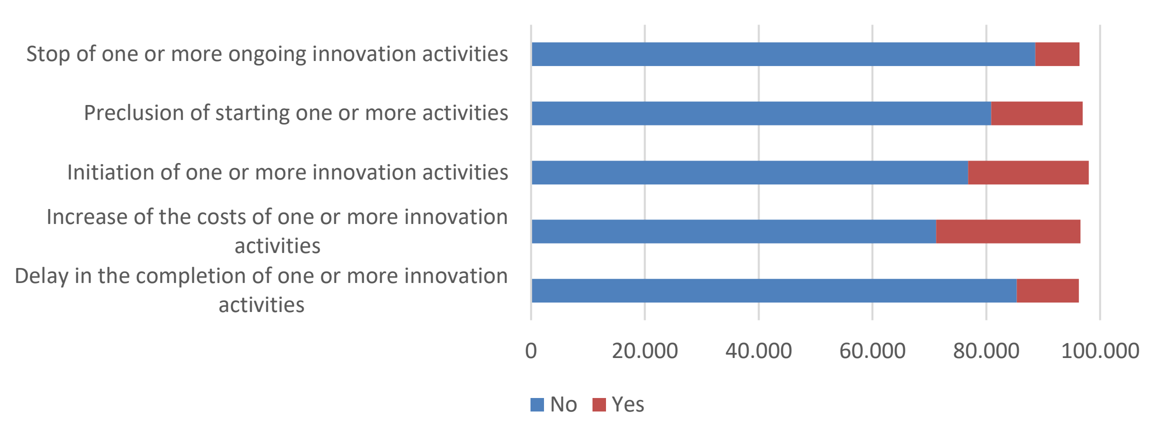
This relationship has also been explored in the Community Innovation Survey, which collects data on innovation activities in enterprises the EU, in both products and processes. The survey explores the effects of legislation and regulation for innovative enterprises, by type of effect. The last published results are from 2016, and they show that around a fourth of companies which have innovation as its core activity experience at least one negative effect due to legislation or regulation. The most frequent effect is "increase of the costs of one or more innovation activities" (26%), followed by "initiation of one or more innovation activities" (22%).

[82] Blind, Petersen, Riillo (2017) The Impact of Standards and Regulation on Innovation in Uncertain Markets Research Policy 46 (1), 249–264, available at: The Impact of Standards and Regulation on Innovation in Uncertain Markets

[83] Palmer, K., Oates, W.E., Portney, P.R., 1995. Tightening environmental standards:the benefit-cost or the no-cost paradigm? J. Econ. Perspect., 119–132.

[84] Porter, M.E., van der Linde, C., 1995. Toward a new conception of the environment-competitiveness relationship. J. Econ. Perspect., 97–118.

Figure 29: Innovative enterprises whose innovation activities have been affected, or not affected, by legislation or regulations, by type of effect



Source: EU Community Innovation Survey (2016), N= 98,023

Despite these examples, the literature exploring the relationship between regulatory instruments and innovation is scarce. There are more examples of literature exploring the relationship between (voluntary) standards and innovation, but again, empirical evidence analysing this relationship is scarce.[85] Formal standards are developed in recognised standardisation bodies and they are voluntary and consensus-driven. In contrast, regulations are mandatory legal restrictions released and enacted by the government. Most studies have not stressed this distinction sufficiently when discussing their impact on innovation.[86]

The literature reviewed suggests that the innovation-standardisation relationship can also be close, dynamic and productive, with standardisation playing different roles (positive or negative) at different stages of an innovation[87] and depending on the extent of market uncertainty[88]. Overall, the literature analysed shows that **the effects of standardisation on innovation depend largely on the status of the technology** (commencement, development or commercialisation)[89], **the way the standard was developed** (e.g. by a network of companies in collaboration, businesses in a competitive environment, or the public sector)[90] and, in relation to this, the **market uncertainty**.[91].

The following table summarises the impact found by ISUG (2002) of standardisation on innovation in function of the stage of the innovation:

[85] For an example of experimental approaches see Agnolli and Bonev (2019) The effect of standardization on innovation. A machine learning approach.

[86] Blind, Petersen, Riillo (2017)

[87] ISUG (2002) Study into the impact of standardisation, Final Report to DG Enterprise

[88] Blind, Petersen, Riillo (2017)

[89] ISUG (2002)

[90] Wiegmann et al. (2017) Multi-mode standardisation: A critical review and a research agenda, Research Policy Volume 46, Issue 8, October 2017, Pages 1370-1386

[91] Blind, Petersen, Riillo (2017)

Stage of innovation	Potential impact
Commencement	At commencement, use of standardised products and systems reduces costs, saves time and assures quality. Standardised parts and modules, with proven quality-assured performance, enable the pre- and early-market stages to proceed faster and at a lower cost. Small or moderate ("adaptive") innovation benefits most from using standardised inputs: mould-breaking (fundamental") innovations are less likely to use standardised components.
Development	In development, standardisation can damage innovation, perhaps fatally, by: • choosing an inefficient technology out of competing alternatives, or • 'freezing' a technology in a premature embodiment, before it blossoms and reaches its potential. Examples of development conflicts between competing standards and technologies in development include VHS/Betamax and Open Systems Interconnection (OSI) versus Internet standards series.
Commercialisation	When an innovation has gone through product development to commercialisation, standards will: • Assure customers that the technology is serious. They assure the consumer of the possibility of other suppliers and convey reliability, solidity and continuity. • Enable add-ons, extensions, further applications, interfaces etc. which can increase the size, depth and attractiveness of the market • Permit more than one company to supply the product, process or service. Customers can be nervous of sole suppliers. Competition also pushes costs down, further increasing customer demand.

It should be noted that this table provides a brief overview of the effects of standardisation on innovation, and not of a mandatory regulation. Therefore, it can serve as a guideline to assess the situation in the baseline, where standards for USB C and USB PD have already been developed (hence the impact of a regulation should be compared to a situation where the standards already exist, and not to a situation where the standards need to be developed).

However, assessing the stage of innovation of USB C and USB PD technologies when the standards were published is not a straightforward task. In addition, in our view, the effects above relate to innovations that are happening in a competitive environment, whereas these standards have been developed in collaboration by a group of companies in the sector. Wiegmann et al. (2017)[92] identified three modes of standardisation: committee-based, market-based and government-based. They argue that the outcomes of standardisation depend on factors such as the timing of their initiation and the institutional context in which the standardisation process occurs.

In committee-based standardisation, standardisation usually happens through cooperation that takes place in committees, consortia or trade associations. Examples provided by the authors of such networks include the International Organisation for Standardisation (ISO), the Blu-Ray Disc Association, or professional associations such as the IEEE. There, stakeholders collaborate to define standards which propose one solution in the form of an approved document. This would be the case of the standards developed by the USB-IF and, therefore the baseline scenario of our impact assessment.

[92] Wiegmann et al. (2017)

In the government-based approach, governments can use their hierarchical position to intervene in standardisation, with regulation being a way of developing and/or diffusing standards. This includes two possibilities: Governments can develop standards themselves and make their use mandatory, or they can impose mandatory use of standards that were developed elsewhere (e.g. by a committee as referred above). The latter would be the case of our policy options, where the EU would make mandatory the use of the standards developed by the USB-IF, and subsequently published by IEC.

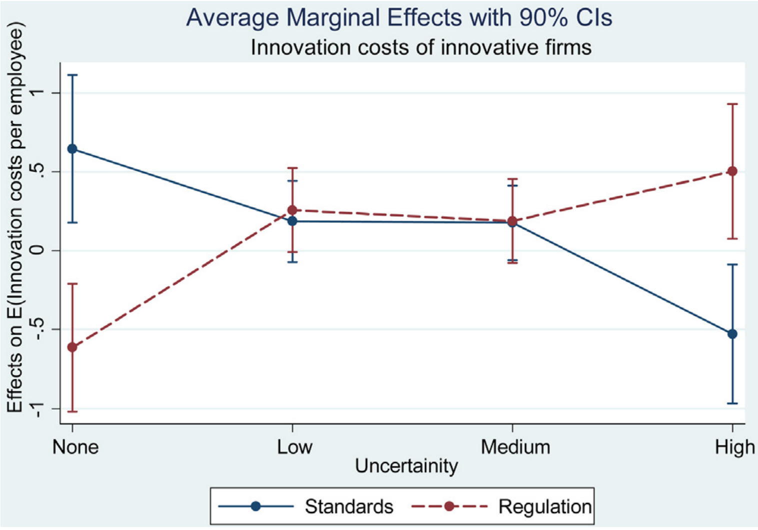
This role of the government has also been discussed among scholars. In general, some researchers justify government intervention because of the benefits of compatibility compared to an alternative situation where there is no common standard. Others argue that avoiding competition between solutions removes the incentive for innovation that would otherwise be needed to ensure a solution's competitive edge, and that governments should therefore carefully weigh the benefits and costs of intervening on a case-by-case basis. In this case, it should be noted, again, that the standards for USB C and USB PD already exist, and therefore the positive impact of regulation on compatibility (or interoperability, in our case) is less evident. However, some scholars add more elements to the equation: Vries and Verhagen (2016)[93] show that government-based standardisation for energy efficiency can also simultaneously stimulate innovation and address societal issues. In other areas (e.g. safety or consumer information standards), government intervention may also be justified in cases of market failure when private actors would settle on solutions which carry negative externalities.

Blind et al. (2017) find that such an intervention's effects on innovation depends on the degree of technological uncertainty in the market. Uncertainty is defined as a situation in which "firms are confronted with a highly heterogeneous technical landscape and unpredictable consumer behaviour. Different technologies may compete against each other and thus increase uncertainty among producers and consumers. […] In this type of market, aside from quality and price as decision parameters, consumers are presented with multiple competing technology options. Waiting for the rise of the dominant technology infrastructure, consumers may postpone buying innovative products, especially if they have difficulties in assessing the intrinsic quality of different technologies".

The authors used data from the Community Innovation Survey in Germany to calculate innovation efficiency, i.e. the capability of a firm to minimise innovation inputs given a certain quantity (or type) of innovation outputs. Only firms investing in innovation (defined as "successful innovators") are included in the analysis. Their empirical findings show that, in low uncertainty markets, firms' innovation efficiency suffers more from standards as barriers to innovation, whereas regulations have a positive influence. In the case of highly uncertain markets, this relationship is inverted. In markets with medium levels of uncertainty, there is no significant difference on the effect of standards and regulations on innovation.

[93] de Vries, H.J., Verhagen, W.P., 2016. Impact of changes in regulatory performance standards on innovation: a case of energy performance standards for newly-built houses. Technovation 48–49, 56–68. https://www.sciencedirect.com/science/article/pii/S0166497216000092?via%3Dihub

Figure 30: Avg. marginal effects of standards and regulation on innovation costs for successful innovators at four levels of market uncertainty



Source: Blind et al. Research Policy 46 (2017) 249–264

The study conducted by Blind et al. uses data in Germany. The authors explain in the limitations of the study that previous research has addressed the point that the interrelation of regulatory instruments might differ between countries (e.g. Prakash and Potoski, 2012; Berliner and Prakash, 2013), and that therefore for further validation the study should be replicated at the international level.

In summary, the **literature is inconclusive** on the effects of standardisation on innovation, the effect of regulation on innovation, and the difference between standardisation and regulation on innovation. Nonetheless, we can identify the following **main conclusions that can be applied to this impact assessment** with more or less robustness:

- The impact of standardisation on innovation depends on the stage of innovation, impacting negatively when the innovation is in development stage, and positively when it is in commercialisation phase, as it provides assurance to consumers about the technology, increasing attractiveness in the market and enabling further applications.

- On the one hand, government intervention may be justified to ensure interoperability or to avoid negative externalities (e.g. to ensure energy efficiency or avoid e-waste). However, it may remove the incentive for innovation.

- In markets with low uncertainty, standards are a higher barrier to innovation than regulations. However, this conclusion needs to be interpreted and used carefully, as it is based only on one study and it has its own limitations (i.e. findings may not apply to this specific case).

In addition, the literature reviewed does not consider the fact that standards and regulations may be more or less restrictive (i.e. standards or regulations may pursue interoperability, quality, safety…), which would also affect how they impact innovation.[94]

[94] A classification of standards is suggested in Blind (2003) The Impact of Standardization and Standards on Innovation, Nesta Working Paper 13/15 November 2013.

Likely impact of the policy options on innovation

There are many interplaying elements in charging solutions: materials used, chemistry, current and voltage applied, type of connectors, etc. Manufacturers often use different combinations of these elements to match the charging profile and the shape of their device. A strict regulation (i.e. mandating for specific power and components), industry warns, would impede them from innovating with (different combinations of) these elements.

Our policy options affect two main elements of the charger, which would affect innovation in very different ways: a) the connector at the device end (Options 1, 2 and 3) and b) the use of certain interoperability standards (option 4) and minimum power requirements (option 5) for the EPS.

The markets for both products are in the commercialisation phase, where the effects of standardisation (or regulation) on innovation are not found to be negative (ISUG, 2002), and both markets can be defined as markets of low or low-medium uncertainty. In the case of the connectors, only three solutions currently co-exist in the market: USB micro-B, Lightning and USB Type C. The first two are well established in the market, whereas the third one has been on the market now for 2-3 years and its use is increasing. Uncertainty in this market is very low. In the case of the EPS, however, there are more solutions that co-exist, as there are several proprietary fast charging technologies, alongside standard chargers. Consumers may have difficulties in assessing the quality of the different technologies and their interoperability. Nonetheless, recently more and more EPS use either USB PD or Quick Charge, or both, reducing uncertainty. In our view, uncertainty in this market is low to medium. From a theoretical perspective, therefore, there is no strong evidence that regulation in these markets may hamper innovation.

The remainder of this sub-section discusses the effects on innovation for each of these elements, connector and EPS, (and their options), based on the literature reviewed, the consultations carried out, and the study team's own judgement.

Options 1, 2 and 3 affect the connector between the cable assembly and the device. Under option 1, proprietary connectors of any sort would be banned. Options 2 and 3, however, allow mobile phones to continue to use proprietary connectors, while mandating the inclusion of adaptors. These two options, therefore, are not expected to impact innovation on the type of connector given that they provide enough flexibility for manufacturers to develop and use proprietary solutions. In addition, they would always have the possibility of selling phones without chargers (decoupling) if they would prefer not to include adaptors in the box.

However, if only USB Type C is allowed at the phone end, manufacturers would no longer have an incentive to invest in the development of proprietary connectors that might give them an advantage over their competitors (and therefore result in potentially significant economic returns from their investment). Instead, future innovation would largely be limited to efforts by the industry as a whole (coordinated via the USB Implementers' Forum) to update or improve the current USB Type C technology, or to eventually replace it with a new generation of common USB connectors. In other words, innovation would still be possible (and indeed, likely to occur), but the rewards of any improved technology would be shared by the sector as a whole. There is a risk that this would slow the pace of innovation overall, and make ground-breaking or "game-changing" innovations outside of the USB framework less likely. The actual significance of this effect is impossible to predict (or even quantify) with any degree of certainty, since we cannot predict what the next innovation would be, when it might occur, and what advantages it would bring. However, to illustrate the potential, we may look at the past for reference. It was widely recognised by the industry that the development of USB Type C connectors was influenced (and to some extent facilitated) by the existence of Lightning. In particular, industry commented that some features of Lightning, including the fact that it is reversible, found their way into the USB Type-C connector. By extension, it appears plausible that the development of future USB technology could be negatively affected by the absence of any competing connector technologies whose features could eventually be incorporated.

In addition, industry argues that other elements of the phone might also be affected. In theory, future proprietary solutions could be smaller or have a different shape, thus making possible, for instance, thinner devices.

Overall, manufacturers agreed that they have a single production line, and would only consider selling phones with different types of connectors in different parts of the world as a last resort (if at all). Therefore, according to industry, such a regulation in the EU would be likely to affect their innovation activities worldwide.

One could argue that innovative (non-USB) connectors could still be developed for those devices that do not fall within the scope of the initiative (assuming that this remains limited to mobile phones). Nonetheless, manufacturers of other devices who were consulted for this study explained that innovation normally happens in mobile phones first, and they adopt those innovations later. Thus, while this would continue to be a possible route for innovation, it is not as significant as the investments made in mobile phones.

In summary, **option 1** could *potentially* have a *major* negative effect in terms of reducing future innovation in phone connectors, both by effectively ruling out any new "game-changing" proprietary connector technology, and by potentially reducing the pace of "incremental" innovation as regards future generations of USB connectors, and limiting the characteristics that this future connector might have. Nonetheless, this needs to be seen in the context of the baseline. In practice, only one company is currently selling phones in the EU that do not use USB connectors at the device end, and even this company has started using USB Type-C connectors in some of its other devices (such as tablets), which makes it seem unlikely it is investing heavily (or sees major potential) in developing a new generation of proprietary connectors. Furthermore, there are no indications that any other company is planning to stop using USB connectors (despite the migration from USB micro-B to USB C). Therefore, overall, we conclude that, in practice, option 1 would be likely to only have a **minor constraining impact** on innovation.

Options 4 and 5 focus on the EPS, requiring interoperability standards and, in the case of option 5, minimum power of 15W.

In our view, **options 4 and 5** are unlikely to affect innovation in a major way. The interoperability standards proposed for option 4 have been described by the industry as "flexible" and have been developed following a participatory approach with representatives from across different sectors in the industry (from chip manufacturers to manufacturers of mobile phones and other devices). The IEC 62680 standard series defines interoperability standards, allowing industry to innovate on other aspects of the charger, and it does not prescribe specific materials, or a minimum voltage or current, for instance. In fact, some proprietary solutions, such as Quick Charge v4, incorporate a functionality that ensure interoperability, demonstrating that proprietary solutions that build on, but go beyond USB PD, would still be possible. However, any new or updated charging solution developed and used in mobile phone EPS in future would have to be compatible with USB Type-C and USB PD. Thus, this option may further boost the existing trend of convergence towards interoperable solutions. At the same time, it does effectively rule out any potential innovations in the field of fast charging that are not interoperable with USB PD. This does represent a restriction on company's freedom to innovate, even though the effect in practice appears likely to be very limited in light of the way the market is evolving at present, and companies' own interest in ensuring interoperability.

Therefore, we conclude that the impact on innovation for each policy option is as follows:

Option	**Impact**
Option 1	- (Minor negative impact on innovation for connectors)
Option 2	0 (Impact is negligible)
Option 3	0 (Impact is negligible)
Option 4	- (Minor negative impact on innovation for fast charging technologies that are not compatible with USB PD)
Option 5	- (Minor negative impact on innovation for fast charging technologies that are not compatible with USB PD)

Decoupling

According to our stock model, major changes in economic impacts per policy option would be expected with **decoupling**. In section 5.1, we defined three different scenarios for decoupling: low, middle and high, all of them with decoupling rates above the baseline. With decoupling, the surplus gained by consumers from savings of not buying chargers in the box would be a detriment for producers, who would forego the income from not selling those chargers. Again, we have calculated changes in costs for consumers and gross profit for the industry, based on the formulae indicated above. The table below shows the difference in the total expenditure of consumers for mobile phone chargers (both included in the box and bought separately), and the differences in revenues for the industry (across the whole supply chain). It compares costs/revenues between the baseline and the three decoupling scenarios (low, mid or high).

Table 34: Economic impacts per decoupling scenario

Cost to consumers (NPV million EUR)	Baseline	Low	Medium	High
Total 2023-2028	10,632	10,211	9,363	7,258
Difference with baseline		-421	-1,269	-3,375
Annual average	1,772	1,702	1,561	1,210
Difference with baseline		-70	-212	-562
As %		-4.0%	-11.9%	-31.7%
Of which gross profit for industry (NPV million EUR)				
Total 2023-2028	6,184	5,945	5,461	4,262
Difference with baseline		-240	-724	-1,922
Annual average	1,031	991	910	710
Difference with baseline		-40	-121	-320
As %		-3.9%	-11.7%	-31.1%

In **summary**, the economic costs and benefits depend primarily on the decoupling rates, rather than the policy options on connectors or type of EPS. Increased decoupling could result in potentially significant savings for consumers of up to €3.4 billion over the duration of the period considered (2023-2028) in the high decoupling scenario. Of these €3.4 billion of savings, part is reflected in the lower gross profit obtained by the industry (reduction of €1.9 billion). The remaining €1.5 billion would be savings achieved due to the lower production of chargers and lower use of raw materials (and hence, lost revenue for charger manufacturers and, mainly, their supply chain).

Among the options that consider different types of connectors and adaptors, **Option 1** is the best option for consumers, who would accrue small savings (or avoidance of extra costs) due to three main factors: a) reduced standalone charger sales (due to enhanced ability to use existing chargers), b) consumers would not have to pay for additional adaptors in the box, and c) cables with USB C connectors have a lower wholesale and retail price than those with Lightning connectors. Our model assumes constant prices, and therefore results may vary slightly if USB C to Lightning were to become cheaper. The current difference observed in the cost may be due to two different elements: the proprietary costs of Lightning, and the fact that USB C to Lightning has been introduced to the market after USB C to C.

Option 1, however, is the least favourable for the industry, and in particular for manufacturers of mobile phones using proprietary solutions. The additional operating cost for these manufacturers is expected to be relatively high, as current models would need to be redesigned or removed from the EU market. It should be noted that these manufacturers are based outside of the EU. This option would also impact the competitiveness of certain businesses, including mobile phone manufacturers using proprietary connectors and their suppliers, who may lose part of the market share of chargers and other accessories against other competitors. This option, in addition, is expected to have a minor constraining impact on innovation, as it may reduce the pace of incremental innovation for future connectors.

Option 2 would imply some costs for consumers due to the inclusion of adaptors, but this is mostly offset by the difference in price between cables using Lightning and USB C, hence the final cost is minor. This option has minor operating costs for the industry and does not affect innovation.

Option 3 is the least favourable for consumers, in terms of economic cost only. The slightly higher price they would have to pay, as compared with the baseline, is due to the higher cost of Lightning (compared with USB C) cables, and the inclusion of adaptors in the box. This option would increase the revenue for the industry.

The **options that consider the EPS** have very little impact on any stakeholder, with small differences in surplus due mainly to the expected reduction in standalone sales of chargers in these scenarios. The low economic impacts as compared to the baseline is because the inputs in our stock model for these options hardly differ from the baseline, given the trend towards interoperable EPS in the market anyways. Under **Option 5** all EPS will provide over 15W, which have a higher cost than EPS with lower power. This cost is partly, but not totally, offset by the reduction in standalone sales of chargers, and this is the reason why Option 4 results in savings for consumers, whereas Option 5 entails a small cost.

5.5 Considerations for implementation

This section discusses key issues related to the potential implementation of the policy options defined previously (see chapter 4), including any significant risks, concerns or question marks about their feasibility from a technical point of view and the extent to which they would be acceptable to key stakeholders. In addition, it addresses the question of the possible policy instruments (voluntary or legislative) to implement each option. Since many of these elements primarily on the part of the charging solution that is being harmonised, the section starts by discussing the connectors at the device end (options 1, 2 and 3), before considering the external power supply (options 4 and 5). The main likely consequences of a possible extension of the scope of the initiative to other portable electronic devices are discussed separately in the ensuing section (5.6).

Connectors at the device end (options 1, 2 and 3)

Technical feasibility

In principle, defining USB Type-C as the common connector between all mobile phones and the charging cable assembly (**option 1**) appears entirely feasible from a technical point of view. USB Type-C is now a relatively mature technology backed by an international standard (IEC 62680-1-3) that was first published in 2016, and has undergone two revisions since. There are no doubts it provides a high-quality charging (as well as data transfer) solution for mobile phones, and the fact that (in combination with USB PD) it is capable of providing up to 100W of power leaves ample room for further development of fast charging solutions.

The only significant concern in this respect is precisely the fact that USB Type-C is already at such a relatively mature stage of its likely life cycle. By 2023, when we assume any new rules would come into force (see section 4.2), our projections (based on recent trends) suggest that USB Type-C will have completely replaced USB micro-B connectors in mobile phones for sale on the EU market. While there are currently no concrete indications of a possible successor to USB Type-C, it appears quite possible that a new generation of connectors will begin to appear around the mid-2020s, if not sooner. This may limit the practical usefulness (and some of the positive impacts) of any attempts to prescribe USB Type-C as the common connector, and means provisions for an eventual shift to a possible successor technology need to be duly considered when pursuing this option (for further thoughts on this see below).

There are also no technical obstacles as such to making adaptors in the box mandatory for manufacturers that choose to continue to use proprietary receptacles in their phones (**options 2 and 3**). Such adaptors are already available for purchase on the market, and there is anecdotal evidence that some manufacturers have in the past included adaptors with their phones in other parts of the world. However, there are concerns around certain unintended negative impacts from this (see the previous sections) and their acceptability to manufacturers and consumers (see below).

Acceptability

Based on the responses to the **public consultation**, option 1 would be popular among EU citizens, with 76% responding they would be satisfied with a single standard connector on the phone end (and 77% with single standard connectors on both ends). However, adaptors to enable the use of different charger types with different mobile phones (as in options 2 and 3) were viewed far less favourably, with only 25% stating they would be satisfied with this course of action. Civil society (including consumer) organisations also tend to favour the highest possible degree of harmonisation.

The **views among industry** of a mandatory adoption of USB Type-C connectors in phones diverged (see also section 3.7). The majority of mobile phone manufacturers and other industry stakeholders consulted were not opposed to USB Type-C as the common device-end connector, and some were actively in favour of any move in this direction. On the other hand, a minority of industry players was opposed to this, claiming it would limit their ability to provide customers with the best technical and design solution in each specific case. In any case, even among those in favour of harmonising connectors, there was a strong preference for achieving this via a voluntary approach, due to the widely held concerns among industry of how regulation would constrain future innovation.

As regards the use of **mandatory adaptors**, most industry representatives consulted were wary of the idea of obliging companies to include an additional component that not all customers may need, but would still have to pay for. Option 2 in particular would be subject to strong opposition from Apple, as in the current circumstances (and assuming it chooses to continue to use proprietary connectors after the new rules come into force) it would oblige the company to ship its phones with a cable that cannot be used to charge the phone it accompanies without the adaptor. On the other hand, it appears Apple might be willing to accept option 3 as a compromise solution.

Consideration of policy instrument

In principle, it would be possible to achieve the desired outcome – namely the exclusive use of USB Type-C connectors in all mobile phones (softened somewhat by the possibility to provide adaptors under options 2 and 3) – via a **voluntary commitment** by the industry. The 2009 MoU, which was signed by all major mobile phone manufacturers at the time, included a similar commitment. However, despite intense exchanges and negotiations over the last several years, industry has so far been unable to agree on a position that would go as far as any of the options considered here. In view of the strong opposition from at least one key player (Apple), it seems unlikely at the present time that options 1 or 2 could form part of a renewed voluntary agreement. This appears more achievable for option 3, which many manufacturers might view as a suboptimal but nonetheless acceptable compromise solution.

If a voluntary commitment to any of the three options were achieved, one would need to pay close attention to the details, in order to determine the extent to which its effects in practice would be identical (or at least similar) to the equivalent regulatory measures. Elements that would require in-depth scrutiny include in particular:

- **Signatories**: Unless signed by all the major manufacturers, the effects of a voluntary agreement would be in doubt. It should be noted that the 2018 MoU proposed by the industry was only signed by seven companies, including the top two in terms of market share, but not number three.

- **Product scope and timeframe:** As noted previously (see section 4.2), we have based our analysis on the assumption that any new rules would apply to *all mobile phones sold* on the EU market from 1 January 2023. By contrast, the 2018 MoU would only apply to *new Smartphone models introduced* to the EU market beginning no later than three years from the date of signing. Whether or not existing models need to comply with the new rules after their entry into force could make a significant difference to the scale of their effects in the first years.

- **Mechanisms to ensure compliance**: The 2014 RPA study found that compliance rates with the 2009 MoU were very high. However, it would need to be considered carefully to what extent a new voluntary agreement would provide guarantees of compliance, and/or mechanisms to detect and penalise non-compliance. Any possible "innovation" clauses would require particular scrutiny, as they might provide a way for signatories to opt out of the commitments they made in case of having developed new (proprietary) connectors.

Possible legal basis

If it were to be determined that regulatory action is required, the question of the legal basis for this arises. While the study team is not in a position (or qualified) to provide a definitive or comprehensive legal analysis, a few observations on this appear pertinent. The most obvious candidate for the legal basis would be the **Radio Equipment Directive** 2014/53/EU (RED). Article 3 (3) of the RED empowers the Commission to adopt delegated acts to specify the categories or classes that are concerned by each of the essential requirements enumerated in paragraph 3, including that "radio equipment shall be so constructed so that they interwork with accessories, in particular with common chargers" (subparagraph a). As such, it appears relatively clear that a delegated act could be used to operationalise the requirement for mobile phones to work with common chargers. However, the power conferred upon the Commission by Article 3 (3) of the RED is widely acknowledged to be quite imprecise, and as a result, **uncertainty** remains as to, for example, what constitutes a "charger" in the sense of the Directive, i.e. which parts of radio equipment are needed to charge a mobile phone. More specifically, considering options 1, 2 and 3 as defined for this study, the RED refers to how "radio equipment" is "constructed", which means it could almost certainly be used to regulate the receptacles on the phone itself. However, whether the corresponding cable assembly including the connectors could also be regulated appears more doubtful, and would require careful legal analysis in order to minimise the risk of legal uncertainty and potentially litigation.

Other issues that would need to be given due consideration when designing a regulatory proposal concerning common connectors for mobile phones include:

- **Technological neutrality and non-discrimination**: The WTO Agreement on Technical Barriers to Trade (TBT) stipulates that technical regulations shall not be discriminatory or create unnecessary obstacles to trade, but also recognises countries' rights to adopt the standards they consider appropriate (e.g. for the protection of the environment or to meet other consumer interests). In light of this, it would need to be assessed carefully whether prescribing a specific technology (in this case, USB Type-C) would be compatible with TBT agreement and other relevant rules.

- **Reviews / updates**: In order not to preclude future innovation, a regulatory initiative would have to enable an eventual transition to a possible successor to the USB Type-C technology. For this purpose, adequate review mechanisms would need to be incorporated.

- **Adaptors**: As noted above, and pending further legal analysis, it appears a delegated act under the RED could mandate a common receptacle on the phone itself, but not necessarily the corresponding cable assembly and connectors. This means that it is unclear whether mandatory adaptors "in the box" (as required under options 2 and 3) would fall within its scope.

Should it be determined that some or all of these issues cannot be satisfactorily addressed via a delegated act under the RED, the Commission would have to consider a revision of the RED itself, or an alternative legal basis.

External power supply (options 4 and 5)

Technical feasibility

From a purely technical point of view, **option 4**, i.e. the requirement for all EPS to comply with the relevant USB standards and specifications does not give rise to any significant feasibility concerns. Many EPS that are supplied along with mobile phones already comply with these. The same is true of **option 5**: requiring all EPS shipped with mobile phones to provide at least 15W of power is undoubtedly technically feasible.

However, there are some question marks about how compliance with the relevant standards would be **monitored and enforced**. Depending on the regulatory approach chosen (see also section 5.4), this might require an additional conformity assessment; depending on whether companies chose to demonstrate conformity via self-declaration of third party testing, this could imply non-negligible additional costs for the companies in question. In the case of IEC 63002, which defines interoperability guidelines for EPS, there is also a question about the extent to which compliance with such *guidelines* could or should be enforced, though this potential obstacle could disappear once IEC 63002 has been revised and more specific requirements added to it.

Another issue that would need to be considered carefully in relation to both options 4 and 5 is that presumably, the new rules and requirements would **only apply to EPS sold "in the box"** together with mobile phones. Obliging these to comply with certain standards (and potentially provide at least 15W of power) would essentially "pull" all such EPS towards what is currently the higher end of the scale in terms of technical specifications. While this would make no significant practical difference for higher-end devices, it would increase the price of lower-end phones, which would have to include a "better" charger than they might require. This could have an indirect effect in terms of encouraging higher decoupling rates for lower-end phones, as manufacturers might choose to not include an EPS in order to be able to offer a lower price. But this in turn could lead to an entirely different kind of issue: the high standards, and hence relatively high price, of "compliant" chargers could make cheaper, sub-standard, potentially counterfeit EPS more attractive to consumers who need to purchase a standalone charger (for details see section 5.2, sub-sections on product safety and illicit markets). This underlines the complications that could arise when defining minimum requirements that apply to charger components (in this case, EPS) when sold with a mobile phone, but not when sold separately.

Acceptability

In the **public consultation**, no questions were asked about interoperability requirements for EPS (option 4). However, the responses suggest that option 5 would be viewed favourably by EU citizens: 80% of respondents would be satisfied with a standardised fast charging solution to ensure optimal performance irrespective of the brand of the mobile phone, and 67% would be satisfied with minimum charging performance rules.

There was no consensus among **industry stakeholders** about the desirability / acceptability of **option 4**. Some phone manufacturers expressed support for the idea of making compliance with the relevant standards mandatory in order to guarantee interoperability between different brands of EPS and phones. Others argued that the current approach of voluntary implementation and enforcement by companies should continue, as companies are naturally incentivised to comply with them as much as possible in order to reduce their risk of being isolated from the rest of the market.

However, they also argued that the extent of (full or partial) compliance is best left to the discretion of companies, which are best able to balance the requirements of their phones and chargers against the cost impact (for design and testing) of meeting the higher specifications.

Regarding **option 5**, industry representatives who expressed an opinion were unanimous in their rejection of minimum power requirements for EPS, mainly because they felt it would unfairly penalise low-end products that do not require more than 5 or 10W to charge them in a reasonable time, and because it would unnecessarily curtail manufacturers' ability to determine the "right" trade-off between speed of charging (which increases with higher power) and battery life of the product (which tends to decrease with higher power).

Consideration of policy instrument

There are no strong reasons per se why a **voluntary commitment** by mobile phone manufacturers to ensure all their EPS for use with mobile phones comply with the requirements defined under options 4 and 5 would not be possible. As part of the 2009 MoU, signatories undertook to "ensure that each EPS […] placed by them on the market for use with Mobile Phones is a Common EPS", i.e. complied with the technical specifications and standards (in particular IEC 62684) developed as a result of the MoU. A similar commitment to the latest standards could be envisaged in principle.

However, the feedback received from mobile manufacturers as part of this study (see above) suggests that some of these would be reluctant to commit to option 4, and all would take issue with option 5. This casts doubts on the ability to reach a voluntary agreement. If one were nonetheless considered, the signatories, product scope and timeframe, and mechanisms to ensure compliance already discussed above would need to be considered carefully to ensure its effectiveness.

Possible legal basis

In case of a regulatory initiative to define a common EPS for mobile phones, it appears **highly doubtful that a delegated act under the RED could be used**. The Directive refers to how radio equipment (incl. mobile phones) is constructed so as to interwork with common chargers, but attempts to use these provisions to regulate the features of the EPS that is used to charge the phones (rather than the phone itself) would be widely seen as beyond its scope, and therefore run a high risk of legal challenge.

A possible alternative legal basis could be the **Low Voltage Directive** (LVD) (2014/35/EU), which covers health and safety risks on electrical equipment operating with an input or output voltage of between 50 and 1,000V for alternating current and between 75 and 1,500V for continuous current.[95] It applies to cables and power supply units.[96] Consumer goods with a voltage below 50V for alternating current are covered by the General Product Safety Directive (2001/95/EC). The LVD is a "total harmonised safety Directive" in the sense that it covers all safety aspects of electrical equipment, not just the electrical risks. Nonetheless, since a possible initiative for a common EPS is clearly not primarily aimed at addressing health or safety risks, whether the LVD could provide an appropriate legal basis also seems highly uncertain.

[95] Voltage ratings refer to the voltage of the electrical input or output, not to voltages that may appear inside the equipment.

[96] Annex VII of the LVD Guidelines provides a number of examples of products that are within the scope of the LVD. It includes cables, cord sets and interconnection cord sets (plug + cable + cord set), multiple travel adaptors with supply (e.g. charger for mobile phones or music player), as well as product with integrated plug and/or outlets. 230V for domestic use (e.g. charger for mobile phones, night lights)

The **Ecodesign Directive** (2009/125/EC) could also be relevant. Its aim is to improve the environmental performance of products (such as household appliances and ICT equipment) by setting out minimum mandatory requirements for the energy efficiency of these products. Its implementing Regulation (EC) No. 278/2009 sets ecodesign requirements regarding the energy efficiency and no-load consumption of external power supplies (including phone chargers). The revised Regulation adopted by the Commission in October 2019 leaves open the possibility for a *future* review to include requirements in support of circular economy objectives, including interoperability.[97] Nonetheless, it remains difficult to see how the *current* scope of the Ecodesign Directive could accommodate the common EPS initiative (with its focus on interoperability and potentially charging performance, rather than energy efficiency).

This means that, to the best of our knowledge, there is no existing piece of EU legislation that lends itself neatly to regulating for a common EPS for mobile phones (and potentially other portable electronic devices). Pending a more in-depth legal analysis, which we are not qualified to provide, it therefore appears likely that a new piece of secondary EU legislation, or an amendment to one of the Directives mentioned previously, would have to be considered. Article 114 TFEU enables the EU to adopt measures to harmonise the legislation of the Member States in order to ensure the establishment and functioning of the internal market. Such measures must take into account the need for a high level of protection of the health and safety of people and of the environment.

[97] Commission Regulation of 1 October 2019; C(2019) 2126 final

5.6 Effects on other portable electronic devices

This section considers (1) the possible indirect impacts on other portable electronic devices of an initiative for a common charger for mobile phones only, as well as (2) the potential for extending the scope of the initiative to include such other devices, and (3) the likely impacts of the latter.

As discussed in section 3.4, we estimate that, in addition to approximately 160 million mobile phones, at least 335 million other portable electronic devices were sold in the EU in 2018 that could potentially be affected by and/or included within the scope of the initiative. Of these, around 75 million were laptops, which have significantly higher power requirements than mobile phones (typically 30-65W), and are therefore not considered further in this context.[98] This leaves **around 260 million devices that have broadly similar charging profiles to mobile phones**, and are therefore relevant to consider further. Among these, the most significant market segments (based on units sold) are wearables (a category which includes a range of devices such as headphones, smartwatches and smart glasses), digital cameras, and handheld videogame devices. Key market trends, as well as the types of connectors that are most frequently used by these devices and the prevalence of decoupling, are summarised in Table 35 below (for additional details and sources, see Annex D). As can be seen, the connectors vary widely between as well as within most product categories, with proprietary connectors playing a significant role for tablets and wearables, while other products use predominantly USB micro-B connectors, and yet others (typically the higher value ones) are beginning to incorporate USB Type-C to a significant extent. And while certain types of devices (in particular e-readers, sport cameras and wearables) are routinely sold without an EPS in the box, for others (again, primarily higher value devices including tablets and digital cameras) there appear to be no "de-coupled" solutions on the market at present.

Table 35: Summary of key sales trends and characteristics of portable electronic devices

Type of device	Est. sales in the EU (units), latest available year	Sales trend, latest three years available[99]	Charging profile (min./max. power)	Prevalence of USB connectors	Prevalence of de-coupling
Mobile phones	158.2m	↘	5-18W	Some USB Type C, some USB micro B, some proprietary	None sold without EPS
Tablets	20.7m	↘	9.36-65W	Some USB Type C, some USB micro B, some proprietary	None sold without EPS
E-readers	16.2m	↘	10-12.5W	Mainly USB micro B	Nearly all sold without EPS

[98] A "typical" laptop charger provides far greater power than a mobile phone needs. While a laptop charger could nonetheless be used to charge a mobile phone (provided both have compatible connectors and incorporate USB PD, which ensures the charger only provides the power "requested" by the phone), the reverse is not true (i.e. a laptop would only charge very slowly with a "typical" mobile phone chargers).

[99] ↑ indicates an increase above 20%, whilst ↗ an increase up to and including 20%. Similarly, ↘ indicates a decrease of 20% or less.

Type of device	Est. sales in the EU (units), latest available year	Sales trend, latest three years available[99]	Charging profile (min./max. power)	Prevalence of USB connectors	Prevalence of de-coupling
Wearables	116m	↗	0.7-10W	Some proprietary, some USB micro B, few USB Type C or wireless	Some sold without EPS
Digital cameras	54.2m	↗	1-10W	Nearly all USB micro B	None sold without EPS
Sport cameras	3.2m	↑	1.3-10W	Some USB Type C, some USB micro B, some USB mini B	Mostly sold without EPS
Videogame devices	52.1m	↗	3-20W	Nearly all USB micro B	None sold without EPS
Laptops	74.4m	↘	30-65W	Nearly all proprietary connectors	None sold without EPS
TOTAL	495m				

Source: *Sales estimates based on various sources, including data from Comtrade and Statista. Product characteristics based on Ipsos's own research (2019) on a sample of 87 products. For details see Annex D.*

For context, it is worth reiterating that, according to the **consumer panel survey** carried out as part of this study (for further details see section 3.5 and Annex C), 22% of respondents also use their mobile phone charger to charge other electronic devices, most frequently tablets and (at a considerable distance) wireless speakers or earphones, or e-readers. When charging such other devices, the majority of respondents use both their mobile phone charger as a whole (cable and EPS); only a small minority uses only one of these elements. On the other hand, 4% of respondents reported using a charger provided with another electronic devices as their main mobile phone charger (and 12% and 17%, respectively, use a charger provided with another device as their secondary or tertiary phone charger).

In the **Public Consultation** (see Annex B), respondents were asked what other similar devices (if any) they believed should be covered by a possible standard charging solution for mobile phones. Nearly nine in ten thought the chargers for tablets should also be standardised. Around three quarters of respondents were in favour of standardising chargers for e-readers, laptops, cameras and smartwatches. There was also majority support (though less unequivocally, at between half and two thirds of respondents) for standardised chargers for GPS navigation systems, battery-powered household appliances, and battery toys.

In what follows, we assess the most significant potential effects of the common chargers initiative (i.e. the different policy options as defined previously) on the devices listed in the table above (with the exception of laptops, which are excluded from the analysis due to their significantly different power requirements). Specifically, for each option, we consider:

- Potentially significant *indirect* effects of the option in question, if implemented for mobile phones only, on the other portable electronic devices.

- Key considerations regarding if and how the option could be extended to these other devices.

- The likely impacts (social, environmental and economic) if the scope of the option were extended to include these other devices.

It is important to note that this study (including the consumer panel survey and the analysis of market data) focused primarily on chargers for mobile phones. For other portable electronic, we do not have access to similarly detailed and comprehensive evidence, and are therefore unable to model the current and likely future stock of chargers, or provide quantitative estimates of the impacts of any of the policy options. Instead, the analysis has to remain qualitative, and limit itself to certain key likely effects and considerations that can be identified based on the information at our disposal.

Connectors (options 1, 2 and 3)

In the first instance, we consider the policy options related to the connectors at the device end. In considering the implications for other portable electronic devices, we focus on option 1 (USB Type-C only). The other options (options 2 and 3) are variations on option 1 that foresee the obligation to include adaptors in the box. The ways in which their effects on other portable electronic devices would differ from those of option 1 mirror those for mobile phones discussed in the previous sections; these are not repeated here.

Indirect effects on other portable electronic devices

Even if the scope of application of the mandatory USB Type-C connectors remained limited to mobile phones only, it appears highly probable that this would have indirect effects on the markets for other portable devices. As noted previously, the fact that such a high proportion of consumers own a mobile phone means these tend to have a certain amount of influence on the market for other devices; for example, the decision of some manufacturers to ship their e-readers, wearables or sport cameras without a complete charging solution (usually with a cable, but without an EPS) is partly motivated by the assumption that nearly all consumers own and are able to use their mobile phone chargers. Therefore, the adoption of a common connector across all mobile phones could be expected to also contribute to a greater and/or faster adoption of this in other electronic devices in which this makes technological, practical and commercial sense (keeping in mind the constraining factors listed below). It could thus reinforce the existing trend of a gradual increase in the take-up of USB Type-C technology and standards, although the extent of this is impossible to predict with any certainty.

Nonetheless, it seems clear that, from a wider "ecosystem" perspective, there are obvious benefits from convergence towards widely-used standards, and there is no reason to believe the market for portable electronic devices (other than mobile phones) would take a different direction. If this were the case, it would reinforce and extend the consumer convenience benefits of option 1 to users of other devices, as it would increase their ability to use the same charger (in this case, the cable) across a wider range of devices. The environmental effects of this would likely be negligible (for the reasons described in section 5.3). Indirect negative economic impacts are not expected, as the adoption of USB Type-C for other devices would remain purely voluntary.

Feasibility of extending the scope to other devices

From a technical perspective, there are no obvious reasons why USB Type-C connectors at the device end could not be used for all common portable electronic devices, including devices with a charging profile that is similar to mobile phones, such as tablets or wearables, but also those with significantly higher power requirements, seeing as (in combination with USB PD) USB Type-C is capable of delivering up to 100W of power. In fact, our analysis (see section 3.4) shows that a small but growing number of devices, even including laptops, already include USB Type-C receptacles and the corresponding cables.

However, making the use of USB Type-C connectors mandatory for chargers of devices beyond mobile phones would give rise to a number of issues and concerns, the most significant of which can be summarised as follows:

- **Cost**: USB Type-C receptacles, connectors and cables incorporate more advanced technical features and materials than many other technologies (incl. earlier generations of USB), and are therefore more expensive to produce. For devices with a low value, and/or that do not require data transfer or other advanced functionalities, industry stakeholders argue that the additional cost would be difficult to justify.

- **Specific types of devices**: There are certain portable electronic devices with specific requirements as regards charging, be it because of their very small size or other design features (e.g. smart watches, hearing aids, etc.), the conditions in which they operate (e.g. underwater cameras, or devices that need to be able to withstand extreme temperatures, such as certain drones), or for other reasons. For some such devices, USB Type-C connectors would not be practical or even feasible. Arguably, a mandatory requirement to use them could also constrain the future development of other innovative types of devices that are only viable with tailor-made connectors.

- **Scope**: To the best of our knowledge, there is no widely accepted definition of what constitutes a "portable electronic device". Therefore, the scope of any attempt to harmonise chargers for such devices would need to be considered very carefully in order to provide legal certainty, as well as exclude devices for which a common charger would not be appropriate (for the reasons outlined above or any others).

Likely impacts of extending the scope to other devices

In light of the uncertainties regarding the exact scope, and the methodological and data limitations alluded to previously, it is difficult to anticipate the exact impacts of the option to make USB Type-C device-end connectors mandatory across a potentially wide range of devices. Nonetheless, assuming the requirement would apply to those devices listed above (tablets, e-readers, wearables, digital and sport cameras, and videogame devices), we can identify the following main likely impacts:

- **Social impacts**: In the consumer panel survey, 49% of respondents had experienced inconvenience from not being able to charge other electronic devices with their mobile phone charger (and 21% reported this had caused them "significant issues" at least from time to time). Other than this, we do not have at our disposal any data specifically on the consumer inconvenience that results from chargers for devices other than mobile phones. Nonetheless, it seems reasonable to assume that the degree and types of inconvenience are broadly similar to those resulting from mobile phone chargers (see section 5.2), although it is worth noting that these "other" devices typically need to be charged less frequently than mobile phones, so certain issues (e.g. not having access to a compatible charger while away from home) are likely to be less common and/or significant.
  On the other hand, while our baseline scenario assumes that USB micro-B connectors will have been completely phased out and replaced by USB Type-C in all new mobile phones by 2022, the same is very unlikely to be the case

across all the other devices (in particular the lower-value ones that have limited or no data transfer requirements). Therefore, in practice, when applied to portable electronic devices other than mobile phones this option would have the effect of not only banning proprietary connectors, but also of speeding up the transition from USB micro-B to USB Type-C. This could result in relatively more significant consumer convenience gains (as a greater proportion of users would be directly affected) than if this option were applied to mobile phones only.
Significant impacts on product safety and/or illicit markets seem highly unlikely.

- **Environmental impacts**: Making USB Type-C connectors mandatory for a wide range of portable electronic devices would be likely to result in only very minor impacts in terms of material use, e-waste and CO_2 emissions. These would stem from (a) the slightly greater weight of USB Type-C connectors and cables, and (b) potential reductions in the sales of stand-alone chargers. We are not in a position to model or estimate quantitatively either of these effects, but, for similar reasons as those outlined in section 5.3, the net effect is likely to be negligible. The impact could be far greater if this option also contributed to higher voluntary decoupling rates, but this would be a very indirect effect and therefore subject to a high degree of uncertainty (for the same reasons as those outlined in section 5.1).

- **Economic impacts**: Regarding the cost implications, similar considerations apply as for mobile phones (see section 5.4). As noted above, an important concern is that USB Type-C cables are more expensive to produce than USB micro-B ones; if they are made mandatory, the additional cost of including such a cable in the box would be passed on to consumers. While the differences are not large (approx. 0.4€ according to our estimates for in the box cables), in relative terms the impact on the retail price of certain low-value devices would be non-negligible. To what extent the same logic applies in the case of a substitution of proprietary (which, in the case of devices other than mobiles, does not necessarily mean Lightning) cables is unclear, as we do not have at our disposal cost or price data for such cables. Similarly, it is possible that the increased cost of the new cables would be partly or entirely offset by savings for consumers due to the reduced need to purchase replacement cables.
  As regards the potential economic impacts on manufacturers of such devices, the cost of re-designing and updating a wide range of devices to include USB Type-C receptacles could be significant for some firms, especially as the rate at which consumers replace these devices tends to be slower than that for mobile phones. Thus, an enforced (and therefore faster) switch to USB Type-C connectors would force firms to re-design their devices and chargers before the end of their "natural" life cycle. Arguably more importantly, it could also mean that certain devices that rely on proprietary connectors for specific reasons (e.g. very small devices or those that operate in specific environments) disappear from the market, or that the development of new such devices is no longer viable (to the detriment of both manufacturers and consumers), unless exceptions were made for certain "specialist" devices.

External power supply (options 4 and 5)

Option 4 would make all EPS interoperable with all mobile phones by requiring them to comply with the relevant USB standards (in particular the interoperability guidelines defined in IEC 63002). Option 5 would add to this the requirement for all EPS shipped with mobile phones to provide at least 15W of power (and therefore comply with USB

PD standards). In what follows, we consider the possible indirect effects of these options, if implemented, on the market for other portable electronic devices, and the scope for, and likely impacts of, making these requirements applicable to chargers for such devices as well.

Indirect effects on other portable electronic devices

The introduction of a "common" EPS for all mobile phones, as postulated by both options 4 and 5, would provide guaranteed interoperability (including backward compatibility with older USB devices), which is expected to also lead to greater consumer awareness of the interoperability of EPS, and confidence in the ability to charge different devices with the same EPS (see section 5.2). This would provide indirect convenience gains for users of other devices (e.g. in terms of reduced confusion), and could also reinforce the existing trend to ship certain devices without an EPS, with the requisite benefits in terms of reduced environmental impacts, and cost savings for consumers. For those devices that would continue to be sold with an EPS, more manufacturers might choose to voluntarily comply with the relevant standards anyway (since, as noted above, the mobile phone market has a certain influence on the market for other devices), which would further enhance the benefits in terms of guaranteed interoperability of chargers across different categories of portable devices (though this is of course highly uncertain). Any potential economic costs are expected to be minimal, since manufacturers of other devices would continue to be free to choose the EPS they consider most appropriate (if any) for each device.

Potential to extend the scope to chargers for other portable electronic devices

In principle, a common EPS for mobile phones that complies with the relevant USB standards (option 4), plus potentially delivers at least 15W of power (option 5), could be used across a wide range of other portable electronic devices with similar charging profiles (but not laptops, which would only charge very slowly with such an EPS).

However, similar considerations to those discussed above under the options for the connectors apply. Unless USB Type-C is mandated to be the common connector at the device end for other portable devices (which would give rise to a number of issues and concerns, as outlined above), some of these devices (especially low-value ones) are likely to continue to use USB micro-B connectors (at least until the cost of USB Type-C has dropped significantly), while certain devices with specific requirements will continue to make use of proprietary (e.g. magnetic) connectors. Although the modern USB technology and corresponding standards that would apply (incl. USB PD) ensure backwards compatibility – i.e. can be used to charge earlier generations of USB devices – it would be difficult to justify the extra cost of such a high-end EPS for devices that do not use USB Type-C and/or USB PD technology, and would therefore draw no benefit from it in terms of charging performance. This is especially the case for option 5, as most of the "other" devices are not used as intensely, or charged as frequently, as mobile phones, and there is therefore less demand for fast charging.

On the other hand, as also outlined previously, it is already relatively common for the kinds of small devices in question (such as action cameras, e-readers, and wearables) to be sold without an EPS. Thus, although a requirement for the EPS – *if* one is included in the box with the device – to meet certain requirements may appear unnecessarily stringent for certain devices, it might not make much practical difference, as manufacturers could choose to not include one (as many already do). In this way, extending option 4 (or 5) to other portable electronic devices could have an indirect positive effect in terms of increasing decoupling rates for certain devices. However, defining the scope, i.e. exactly which types of devices should be included, would require careful consideration (for similar reasons as those outlined under the connector options above).

Likely impacts of extending the scope to other devices

The likely impacts of requiring all EPS that are shipped with tablets, wearables, digital cameras, and the other portable devices listed above to comply with USB standards (option 4), and delivering at least 15W of power (option 5), needs to be seen against the backdrop of the considerations outlined above. For example, for tablets, the requirement to include such a "high end" EPS would lead to impacts broadly along the same lines as those for mobile phones discussed in the previous sections (though it needs to be noted that the market for tablets is much smaller than that for mobile phones, so in absolute terms the impacts would be less significant). However, for many of the other, less sophisticated and less expensive devices within the scope, manufacturers and distributors would essentially be faced with the choice of either including an unnecessarily high end EPS, or avoiding this by not including an EPS at all. The environmental and economic impacts of these options would largely be driven by which of these most manufacturers ended up choosing:

- **Social impacts**: The impact in terms of consumer convenience is likely to be positive, as the EPS shipped with both mobile phones and a wide range of other devices under option 4 would be highly interoperable across different types of devices, reducing confusion as to which chargers works with what, and enhancing flexibility for consumers. Under option 5, this would also include guaranteed high charging speeds (although it is unlikely that all devices would incorporate the technology required to be able to take advantage of this).

- **Environmental impacts**: The slightly heavier EPS that would be required could have a minor negative impact in terms of material use, e-waste and CO_2 emissions. These could potentially be (partly) offset, or even outweighed, by a reduction in the sales of (in the box and/or stand-alone) EPS, but the extent to which these would occur are impossible to predict with any certainty.

- **Economic impacts**: Again, the net effect would depend on the extent to which these options would lead to greater sales of devices without EPS. In the "worst case" scenario, large numbers of consumers would end up paying a premium for an EPS that far exceeds the actual requirements of the device it comes with (while manufacturers and distributors would gain extra revenue, unless the increased price due to the EPS led to a decrease in consumer demand). In the "best case" scenario, an increased number of devices would be sold without an EPS in the box, and consumers would resort to their mobile phone chargers instead.

In summary, options 1, 4 and 5, even if made mandatory for mobile phones only, all are likely to have indirect benefits on the market for other portable electronic devices, due to their potential to foster greater convergence as well as increased decoupling on these markets. However, the scale of any such indirect effects is very difficult to estimate with the information at our disposal.

If the scope of application of these options were to be extended to include other portable electronic devices (including tablets, but not laptops), the exact scope would have to be defined very carefully, in order to provide the maximum possible coverage and legal certainty, while avoiding unnecessarily limiting the flexibility for certain "specialist" devices to use different connectors in cases where this is justified by their nature, size and/or intended uses.

As regards the main impacts, there are trade-offs to consider between the increased consumer convenience of having a single common charger across different types of devices, and the fact that certain (relatively simple and inexpensive) devices do not "need" a charger that is sophisticated (and fast) enough to charge a modern high-end mobile phone. The consumer benefits of making such a charger mandatory would therefore have to be weighed against the cost implications, as well as the potential for slightly negative environmental impacts. For example, while the benefits would be likely to outweigh the costs for certain devices that are broadly similar to mobile phones (such as tablets), the same is not necessarily the case for other categories of devices that have significantly different uses, functionalities and price ranges (such as many wearables).

6. COMPARISON OF OPTIONS

This chapter provides a summary of the various impacts of the options and scenarios, as analysed previously. For some of these impacts (environmental impacts and financial costs), we are able to provide quantitative estimates based on the stock model. The types of impacts for which this is not possible are assessed in qualitative terms. To facilitate comparison, we have used a multi-criteria analysis (MCA) approach, and converted all effects into a common "currency" (from a "major positive" to a "major negative" impact). These are shown in the summary tables below. For the detailed assessments, quantitative estimates, considerations and assumption underlying these, please refer to chapter 5.

6.1 The likely impacts of the policy options

<u>Summary overview</u>

The summary table overleaf shows the impacts of the five policy options as such (applied to mobile phones only) relative to the baseline, and without taking into account any potential effects from increased voluntary decoupling that might follow from the options, or effects on other portable electronic devices (these are discussed separately below). As can be seen:

- **Social impacts**: Options 1, 4 and 5 would increase consumer convenience overall, mainly due to the enhanced ability to charge different phones with different chargers, the increased likelihood of finding a compatible charger while away from home (option 1), and/or reduced confusion about which charger works with what (options 4 and 5). There are also marginal benefits in terms of product safety and the illicit market from all options except option 3, due to the expected small reductions in demand for (potentially unsafe and/or counterfeit) stand-alone chargers (for details see section 5.2).

- **Environmental impacts**: Relatively minor impacts occur due to (1) the small differences in weight between different charging solutions, and (2) reductions in stand-alone charger sales. The combination of these effects results in a very small positive net impact for option 4; a very small net negative impact for options 1, 2 and 3; and a slightly larger net negative impact for option 5 (for details see section 5.3). The impact of the options, particularly options 1, 2, 4 and 5, is quite sensitive to the assumptions on the impact they have on standalone sales, these assumptions are based on limited data and should be treated cautiously.

- **Economic impacts**: The price differences between different charging solutions, and the potential reductions in stand-alone charger sales, would result in net savings for consumers under options 1 and 4 (although under the latter these would be very small). Options 3 and 5, on the other hand, would impose additional costs on consumers (due to the cost of the adaptors or relatively higher cost of fast chargers), which are mirrored by an increase in revenue for the mobile phone industry. The other options would lead to a decrease in industry revenue, but this is likely to be on a scale that is (almost) negligible, expect for option 1 (which could also negatively affect the competitiveness of some firms in the supply chain). Some options would also entail adaptation costs for mobile manufacturers, but these are expected to be very minor except, again, in the case of option 1. Options 4 and 5 are expected to result in minor administrative / compliance costs (related to conformity assessment). Options 1, 4 and 5 would have a minor constraining impact on innovation (for details see section 5.4).

Table 36: Summary of the impacts of the policy options

Impacts		**Connectors at the device end**			**EPS**	
		Option 1 USB Type-C only	**Option 2** USB Type-C only; for phones with proprietary receptacles, adaptors in the box compulsory	**Option 3** USB Type-C or proprietary; for cables with proprietary connectors, adaptors in the box compulsory	**Option 4** Guaranteed interopera-bility of EPS	**Option 5** Interopera-bility plus minimum power require-ments for EPS
Social	Consumer convenience	+	0	0	+	+
	Product safety	0/+	0/+	0	0/+	0/+
	Illicit markets	0/+	0/+	0	0/+	0/+
Environ-mental	Material use	-/0	-/0	-/0	0/+	-/0
	E-waste & waste treatment	0	-/0	0	0	0
	CO_2 emissions	0	-/0	-/0	0/+	-
Economic	Operating costs for businesses*	-	-/0	0	0	-/0
	Administrative burdens for businesses*	0	0	0	-	-
	Competitive-ness of businesses*	-	0	+	-/0	+
	Costs for consumers	+	-/0	-	0/+	-
	Innovation and research	-	0	0	-	-

++ Major positive impact *+ Minor positive impact* *0 No or negligible impact* *- Minor negative impact* *-- Major negative impact*

** The options affect different kinds of businesses in different parts of the world in different ways; for details please see section 5.4.*

NB: All impacts are relative to the baseline scenario. Effects on voluntary decoupling or indirect effects on other portable electronic devices that may results from the options are not included in the scores.

In addition to the main impacts included in the table above, it is important to consider the following **potential wider impacts**. These relate to issues that were also considered as part of this study, but in less detail and with a more limited evidence base, and for which it is therefore not possible to make specific predictions and estimates, but which are nonetheless important to keep in mind (for further details see section 6.2 below):

- **Decoupling**: All of the policy options (especially the ones that relate to the EPS) have a potential indirect effect on decoupling rates. Although the evolution of the market in the last ten years suggests that further harmonisation of chargers alone is unlikely to lead to increased decoupling, the higher interoperability that would follow from this could be a contributing factor in any efforts to achieve this. In view of the high degree of uncertainty, any potential effects on decoupling rates are not incorporated into the comparative analysis of the policy options per se. Nonetheless, the potential indirect contribution of the options to decoupling – and the environmental benefits that would follow – should be acknowledged and taken into account.

- **Indirect impacts on other portable electronic devices**: Options 1, 4 and 5, even if applied to mobile phones only, are likely to have indirect impacts on the market for other portable electronic devices, i.e. foster convergence on the same charging solutions for at least some other devices, which would provide additional consumer convenience benefits.

- **Impacts of a possible extension of the scope to other portable electronic devices**: If the initiative (i.e. any of the options) were extended to apply to other portable electronic devices, the consumer convenience gains would be extended to users of such devices, due to the greater interoperability of chargers (EPS and/or cables) with different classes of devices. However, the economic costs would also increase, which is a particular concern for certain low-value devices which would have limited need for high-end (and therefore more expensive) charging technologies.

It should further be noted that the effects of all options are subject to a certain degree of **residual uncertainty** regarding the extent to which they are "future-proof". This is inevitable, since the natural reluctance of economic operators to divulge information about their future commercial and technological plans and strategies makes it impossible to accurately predict the future evolution of the relevant markets in the absence of EU intervention. The following key question marks are worth keeping in mind:

- **Use of proprietary connectors**: In the absence of any clear indications to the contrary, the baseline used for the study assumes that proprietary connectors will continue to be used on the same scale as today until 2028 (the end of the period modelled). Nonetheless, it is possible (though it appears unlikely at the present time) that individual manufacturers phase out existing proprietary connectors (i.e. Lightning) and/or introduce new ones. If we assumed the latter (i.e. further fragmentation), then the impacts of option 1 in particular could be far more significant.

- **Transition between current, and emergence of future, generations of USB technology**: This study assumes that any new rules would come into effect in 2023. An earlier entry into force would be likely to lead to more significant (positive as well as negative) impacts, as it could speed up the ongoing transition to the new USB technologies (i.e. USB PD and Type-C). In addition, it is worth noting that USB Type-C is now a relatively mature technology. While there are currently no concrete indications of a possible successor (a hypothetical "USB Type-D"), it appears quite possible that a new generation of USB connectors will begin to appear sometime in the next decade. If this occurs relatively soon (i.e. in the first half of the 2020s), it would reduce the benefits of option 1.

- **Wireless charging**: Wireless charging is a very incipient technology. At present, its energy efficiency and charging speed cannot match those of wired solutions, and there are no indications that wireless charging is likely to become the dominant solution, or even make wired charging obsolete, in the foreseeable future. However, if any breakthroughs in wireless charging technology were to change these basic parameters, this could undermine the rationale for the initiative as framed by this study, by significantly reducing the relevance of wired charging solutions in general.

The impacts of the policy options in more details

More specifically, the main impacts of, and differences between, the five options can be summed up as follows:

Option 1: Only cable assemblies with a USB Type-C connector at the device end are allowed. Cable assemblies that require adaptors are not considered compliant.

- **Main benefits:** As discussed in section 5.2, this would ensure that all consumers can use the cable supplied with their mobile phone to charge any mobile phone irrespective of the brand or model (and potentially also a wide range of other portable electronic devices), and increase the likelihood that users who run out of battery, but have no access to their own charger (e.g. because they are travelling), are able to find a compatible charger. This needs to be seen in the context of the expectation that, in the baseline scenario, around 80% of phones sold in the EU will come with USB Type-C connectors anyway by 2023, which somewhat limits the marginal benefits of this option. There would also be a small saving to consumers, due to the slightly lower cost of USB Type-C cables compared with Lightning, and the reduced need to purchase stand-alone chargers (see section 5.4). The latter would be likely to also result in a small reduction in the market for unsafe and/or counterfeit chargers.

- **Main costs**: This option would entail significant adaptation costs and foregone revenue for manufacturers that currently use proprietary connectors in their phones (and parts of their supply chain), and could constrain future innovation by effectively ruling out any new "game-changing" proprietary connector technology (though this appears unlikely at present), and by potentially reducing the pace of "incremental" innovation as regards future generations of USB connectors (see section 5.4). There could also be very minor (in some cases negligible) negative environmental impacts on materials use, waste and GHG emissions due to the slightly higher weight of USB Type-C connectors compared with Lightning (see section 5.3).

- **Other considerations:** USB Type-C is now a relatively mature technology and as such does not raises any technical concerns. However, it appears possible that, by the time new rules come into force (we assume 2023), a new generation of (USB) connectors will begin to appear quite soon, which would limit the practical usefulness (and some of the positive impacts) of this option, and means provisions for an eventual shift to a possible successor technology need to be duly considered when pursuing this option (see section 5.5). As regards its acceptability, the Public Consultation suggests a majority of EU citizens would be strongly in favour of this option. The majority of mobile manufacturers consulted for this study also had no objections to this option in principle, but expressed a preference for pursuing it via a voluntary agreement. However, this seems unlikely to be achievable in view of the strong opposition from at least one major manufacturer. If regulatory action is to be taken, a delegated act under the RED could be envisaged, but there remains an element of uncertainty regarding its scope that would necessitate further careful legal analysis.

Option 2: Only cable assemblies with a USB Type-C connector at the device end are allowed. Manufacturers that wish to continue to use proprietary receptacles in their phones are obliged to provide an adaptor from USB Type-C to their proprietary receptacle in the box.

- **Main benefits:** This option would entail minor positive as well as negative impacts for different types of consumers. While the proliferation of cables with USB Type-C connectors would reduce inconvenience for some users (as described above), users of phones with proprietary receptacles would be inconvenienced by the need to use the adaptor each time they charge their main phone. The only other likely benefit is a small reduction in demand for stand-alone chargers, and hence in the market for unsafe and/or counterfeit chargers.

- **Main costs**: The adaptation costs and constraints on future innovation that would follow from option 1 (see above) are alleviated or eliminated under this option, assuming certain manufacturers choose to continue to use / invest in proprietary solutions in spite of the inconvenience this would cause their customers. Minor negative environmental impacts would follow from the need to ship slightly heavier cables as well as adaptors (and the expected reduction in stand-alone sales is not significant enough to offset these). Any net differences in consumer cost and industry revenue are negligible (since the different factors tend to offset each other).

- **Other considerations:** While this option may seem like a viable compromise solution at first, closer scrutiny leads us to conclude it would not generate any net benefits. The Public Consultation results suggest that consumers are not keen on adaptors, and the industry is also wary of the idea of obliging companies to include an additional component that not all customers may need, but would still have to pay for. As a result, it seems unlikely this option could be implemented via a voluntary agreement. If regulatory action is to be taken, the uncertainty alluded to above regarding the use of a delegated act under the RED would be even greater under this option, as it is unclear whether the RED could be used as a legal basis to define the essential requirements of accessories (as opposed to the phone itself).

***Option 3*:** Cable assemblies can have either a USB Type-C or a proprietary connector at the device end. Manufacturers that choose to provide a cable with a proprietary connector are obliged to provide an adaptor in the box that enables its use with a USB Type-C receptacle.

- **Main benefits:** This option would generate minor positive impacts for some consumers only. By taking advantage of the adaptor provided, users of phones with proprietary receptacles could use the corresponding cable to also charge other devices (incl. phones) with USB Type-C receptacles. However, the majority of users who own mobile phones with USB Type-C receptacles would reap no benefits from this option. Thus, the only “benefit” that follows from this option is the industry revenue from the sale of adaptors.

- **Main costs**: This option eliminates any significant adaptation costs or innovation constraints for manufacturers, but would result in small additional cost for some consumers (the cost of the adaptor), which would also have very minor environmental consequences.

- **Other considerations:** It may be possible for industry to commit to this option voluntarily, as many manufacturers view it as a suboptimal but nonetheless acceptable compromise solution. However, it would need to be considered whether this would be worthwhile, given the very limited benefits (and corresponding costs). As with any voluntary initiative pursuant to any of the options, the signatories, product scope and timeframe, and mechanisms to ensure compliance would need to be considered carefully to ensure its effectiveness.

Option 4: Commitment to ensuring all EPS for mobile phones are interoperable. This would be concretised via reference to compliance with relevant USB standards, in particular the interoperability guidelines for EPS (IEC 63002), which are currently being updated.

- **Main benefits:** EPS shipped with mobile phones can typically already be used to charge a wide range of other phones / devices. However, there are no guarantees of this, and many consumers' awareness of the extent to which EPS are interoperable with different phones appears limited. This option would *extend* and *guarantee* the interoperability to all modern mobile phones (as well as other devices implementing the USB Type-C and/or USB PD standards), which could be expected to enhance consumer awareness of and confidence in this, and reduce confusion. The impact on the sales of standalone chargers would lead to minor environmental benefits in terms of emissions, material use and waste, very minor overall cost savings for consumers, as well as a small reduction of the sales of unsafe and/or counterfeit chargers.

- **Main costs**: The interoperability standards that all EPS would have to comply with under this option are very flexible, and do not pose any major concerns as regards innovation. Nonetheless, this option does effectively rule out any potential innovations in the field of fast charging that are not interoperable with / based on USB PD – but the fact that there is a clear market trend towards charging solutions that are compatible (though not necessarily fully compliant) with USB PD anyway means the effect in practice would be likely to be limited. There would also be economic costs for economic operators related to the conformity assessment and/or certification process that would likely be required to ensure compliance, as well as a very minor decrease in revenue from stand-alone sales.

- **Other considerations:** There are open questions about how compliance with the relevant standards would be monitored and enforced, which could require an additional conformity assessment process and imply additional costs. Also, this option could increase the price of lower-end phones, which would have to include a "better" EPS than they might require. This could have an indirect effect in terms of encouraging higher decoupling rates for lower-end phones, as manufacturers might choose to not include an EPS in order to be able to offer a lower price. Industry views on this option are mixed, and a commitment to implementing it voluntarily therefore appears unlikely. At the same time, it appears unlikely that the RED, LVD or Ecodesign Directives would provide a solid legal basis for defining interoperability requirements for the EPS, which means that new secondary legislation might be required.

Option 5**:** To facilitate adequate charging performance, all EPS for mobile phones would have to guarantee the provision of at least 15W of power (in line with most current fast charging technologies). To also ensure full interoperability, all EPS would have to be capable of "flexible power delivery" in accordance with common (USB PD) standards / specifications.

- **Main benefits:** This option would deliver the same consumer benefits as option 4 (see above). In addition, it would ensure consumers are able to charge their phones with another charger at a similarly fast speed, and thereby largely eliminate a source of inconvenience experienced by the majority of consumers (according to our panel survey). It would provide a small benefit to producers due to the higher cost (and price) of fast chargers. It is also expected to lead to a slightly more significant reduction in stand-alone charger sales than any of the other options, with the requisite benefits in terms of fewer unsafe and/or counterfeit chargers.

- **Main costs**: This option would result in similar innovation constraints and administrative / compliance costs as option 4. It may also generate adaptation costs for manufacturers of low-end mobile phones, which would need to move towards USB PD a bit faster than the current pace. The cost for consumers is expected to be higher than in the baseline (since all EPS would have to provide over 15W), although this would be somewhat offset by the savings from the reduced need to purchase stand-alone chargers. The heavier EPS also lead to the second highest material consumption impact of the options, comparable to option 3, and also the highest emissions impact.

- **Other considerations:** The questions about the conformity assessment process and its costs raised above also apply to option 5, while the concerns about the potential price impact on in-the-box chargers would be exacerbated by adding minimum power requirements. Respondents to the Public Consultation were strongly in favour of standardising fast charging solutions and/or setting minimum performance rules, but industry representatives who expressed an opinion were unanimous in their rejection of this option, not only because they felt it would unfairly penalise low-end products that do not require more than 5 or 10W to charge them in a reasonable time, but also because it would curtail manufacturers' ability to determine the "right" trade-off between speed of charging (which increases with higher power) and battery life of the product (which tends to decrease with higher power). A voluntary agreement therefore seems very unlikely. As regards regulatory action, the same considerations regarding the possible legal basis as under option 4 apply.

In summary, options 1, 4 and 5 would generate benefits in terms of **consumer convenience**. These vary by option, sub-group of consumers, and situation (the different options would mitigate the different main sources of inconvenience experienced by consumers in the current situation to varying degrees). These benefits need to be seen in the context of the dynamic baseline scenario, which envisages certain key trends (in particular the complete substitution of USB micro-B by USB Type-C connectors at the device end, and market convergence towards fast charging technologies that are compatible with USB PD) that are likely to decrease consumer inconvenience anyway. This means that the additional benefits from all options when they come into force (assumed to be 2023) will be smaller than they would be in the current situation (2019). There would also be minor cost savings for consumers from options 1, and very minor cost savings from option 4.

All options are likely to have **economic costs**, some of which may be non-negligible, and would therefore need to be weighed up against the consumer benefits. In addition, there are certain **risks** and issues related to the technical feasibility, acceptability, and most appropriate policy instrument that would need to be carefully considered.

We also conclude that all of the options as formulated, except option 4, are likely to have a very small negative **environmental impact** on material use, waste and GHG emissions, as they would lead to subtle changes in the types of charger components and/or accessories. The modelled indirect impact of reduced standalone sales would not offset the impact of heavier (USB C cable or EPS) components. Only Option 4 provides a very small positive impact compared to the baseline as it results in no tangible physical difference in charger types, but does allow for a small reduction in standalone sales. Reducing the number of chargers is the best way to reduce environmental impacts and would only occur at large scale via decoupling, which was assessed separately (see below).

It should be noted that, in principle, any of the options for the device-end connectors (options 1, 2 or 3) could be combined with one of the options for the EPS (options 4 or 5). We would expect the effects (both positive and negative) of such a **combination of options** to be cumulative – for example, the consumer convenience benefits of an initiative that combined options 1 and 4 would be higher than those from either of these options in isolation, and their combination should also result in a more significant reduction in stand-alone charger sales (roughly the sum of the effects of both options individually). The effects in terms of the weights and costs of the different charger components can also be added up. Therefore, we can be reasonably certain that the net impacts of the combination of two options (including the environmental and economic impacts estimated via the stock model) would be the sum of the impacts of the options individually.

6.2 Other considerations

Decoupling

In theory at least, the EU could legislate to make decoupling compulsory (i.e. require mobile phones to be sold without an EPS, or even with neither a cable nor an EPS). However, this study **has not considered mandatory decoupling** as an option, because it would have exceeded the scope of the initiative as framed by the European Commission (namely to focus on a "common charger"), and would have required a different set of approaches to the data collection and analysis to assess its likely impacts, risks, etc.

However, we have considered the extent to which the initiative as currently framed could help to **facilitate voluntary decoupling**, i.e. lead economic operators to offer phones without chargers (without being required to do so), and their customers to make use of this option. To do so, we have defined three decoupling scenarios (lower, mid and higher case), to estimate the effects on voluntary decoupling that appear feasible (for details see section 5.1).

We have also considered the extent to which the preconditions for increased decoupling are likely to be affected by each of the specific policy options, and hence **which of the scenarios appears most relevant**. This led us to conclude that the options that are focused on the device-end connectors (options 1, 2 and 3) in isolation (i.e. without any other accompanying measures) would be very unlikely to lead to anything more than the lower case scenario. The EPS options (options 4 and 5) have the potential to facilitate more significant decoupling, up to the mid case scenario. The highest possible rates only appear plausible as a result of the combination of the maximum harmonisation options for both the device-end connectors and the EPS.

However, it is important to re-emphasise that this would depend on a range of factors, including possible accompanying information campaigns or other measures taken by the Commission and/or other public authorities, and the specific commercial and other decisions made by economic operators. Therefore, the considerations summarised here (and explained in further detail in section 5.1) should be interpreted not as firm predictions, but only as illustrations of the potential effects of the options. The very high degree of **uncertainty** should always be kept in mind.

With this in mind, **Table 37** summarises the impacts we expect to be achieved by each of the decoupling scenarios. **In summary**, the higher the decoupling rates, the greater the environmental benefits (for quantified estimates see section 5.3) and the cost savings for consumers (see section 5.4), as well as the convenience benefits for the large number of consumers who feel they have too many chargers taking up space in their home and/or workplace. However, the higher decoupling scenarios would also be likely to lead to a certain growth in the market for standalone chargers and, by extension, in the sales of unsafe and/or counterfeit chargers.

Table 37: Summary of the impacts of the decoupling scenarios

Impacts		**Decoupling scenarios**		
		Low (max. 5% for EPS, 2.5% for cables)	**Mid** (max. 15% for EPS, 7.5% for cables)	**High** (max. 40% for EPS, 20% for cables)
Social	Consumer convenience	0	0/+	+
	Product safety	0	-/0	-
	Illicit markets	0	-/0	-
Environ-mental	Material use	+	+/++	++
	E-waste & waste treatment	+	+/++	++
	CO_2 emissions	+	+/++	++
Economic	Cost for consumers	+	+/++	++
	Margin for producers	-	-/--	--

++ Major positive impact *+ Minor positive impact* *0 No or negligible impact* *- Minor negative impact* *-- Major negative impact*

NB: All impacts are relative to the baseline scenario, which assumes no decoupling.

<u>Other portable electronic devices</u>

Finally, the study was also tasked with analysing the possible *indirect* impact on the EU market for other small portable electronic devices requiring similar charging capacity. This was not the main focus of the study, and the evidence base as well as the breadth and depth of the analysis is therefore more limited. Nonetheless, as regards impacts on other portable electronic devices, two key questions were considered (for further details see section 5.6):

Would a common charger for mobile phones have indirect effects on the markets for other portable devices?

The fact that such a high proportion of consumers own a mobile phone means that phones have an influence on the market for other devices. For example, it is already relatively common for some small devices (such as action cameras, e-readers, and wearables) to be sold without a complete charging solution (usually with a cable, but without an EPS); this is based partly on the expectation that customers will be able to use their mobile phone chargers. The adoption of a common connector and/or EPS across all mobile phones could therefore be expected to also contribute to a greater and/or faster adoption of this in other electronic devices in which this makes technological, practical and commercial sense (which would likely be the case for many but not all small devices; see below). It could thus reinforce the existing trend of a gradual increase in the take-up of USB Type-C und USB PD technology and standards in other markets, with the requisite convenience benefits for users of such devices. In turn, this could also have the indirect effect of increasing decoupling rates for certain devices.

Could / should the scope of a possible initiative be extended to include devices other than mobile phones?

From a technical perspective, both USB Type-C connectors (option 1) and compliant EPS (options 4 and 5) could be used for a wide range of devices, including tablets, e-readers, wearables, and even laptops (although the latter require significantly more power, and would therefore only charge very slowly with the kind of EPS envisaged here). Having a single common charger across different types of devices would be likely to increase consumer convenience overall.

However, making the use of such chargers (connectors and/or EPS) mandatory for devices beyond mobile phones would give rise to a number of issues and concerns, the most significant of which are: cost implications (requiring devices, especially low value ones, to ship with a charger that is more sophisticated and/or powerful than required would increase their cost for consumers); devices with specific requirements (e.g. very small devices, or those that operate in extreme environments, and for which USB Type-C connectors would not be appropriate); and, loosely related to this, the product scope (in the absence of a usable definition of what constitutes a "small portable electronic device", the types of devices covered would need to be considered very carefully).

Specifically regarding options 4 and 5, these concerns could be partly mitigated by the following consideration: as outlined above, certain kinds of small devices are already routinely sold without an EPS. Thus, although a requirement for the EPS to meet certain requirements may appear unnecessarily stringent (and expensive) for certain devices, this could lead more manufacturers to choose to not include one. In this way, extending option 4 (or 5) to other portable electronic devices could have a positive effect on voluntary decoupling rates for such devices, and lead to fewer EPS being produced and discarded.

6.3 Concluding remarks

Based on our analysis of the likely social, environmental and economic impacts of the options defined for this study, there is no clear-cut "optimal" solution. Instead, all options involve **trade-offs**, and whether or not the marginal benefits (compared with the baseline) are deemed to justify the marginal costs is ultimately a political decision that also needs to take into account the residual risks and uncertainties identified by the study.

The **main problems** the initiative on common chargers is intended to address are (1) the consumer inconvenience that arises from the fragmentation that remains (which affects the majority of mobile phone users in the EU, although most do not regard it as a very serious issue), and (2) the negative environmental effects that result from the large number of (arguably unnecessary) chargers produced and eventually discarded (mobile phone chargers are currently responsible for around 12,000 tonnes of e-waste per year, which represents approx. 0.3% of total WEEE collection in the EU).

As the analysis has shown, options 1, 4 and 5 would address different facets of **consumer inconvenience** to varying degrees (but options 2 and 3, which were devised as possible compromise solutions, would not generate any significant net benefits in this respect, and are therefore unlikely to be worth pursuing further). A combination of option 1 with options 4 or 5 would result in the most significant consumer convenience gains. However, it should be noted that further convergence towards USB Type-C connectors as well as fast charging technologies that are compatible with USB PD is expected to occur anyway. This means that the marginal consumer convenience benefits would be minor rather than major, and result mainly from the *elimination* under option 1 of proprietary connectors (which, under the baseline scenario, are assumed to continue to account for a little over 20% of the market), and/or the *guarantee* that all EPS will be interoperable with all mobile phones (options 4 and 5), which in practice is already the case for the majority of EPS today (and appears likely to increase further under the baseline scenario).

As regards the negative **environmental impacts** generated by the current situation, all options have the *potential* to contribute to mitigating these to some extent by facilitating voluntary decoupling. However, the extent to which this would occur in practice is highly uncertain, and the ineffectiveness of the first (2009) MoU in this respect raises serious doubts that decoupling would follow automatically from the standardisation of chargers (especially connectors) alone. Therefore, the policy options assessed in this study *per se* are unlikely to generate significant environmental benefits (in fact, most are likely to result in very minor environmental costs). Achieving a reduction in material use, e-waste, and GHG emissions would require additional measures to facilitate and/or incentivise the sale of mobile phones without an EPS and/or cable assembly. A more in-depth analysis would be needed to determine if and how this could be achieved via non-regulatory or regulatory measures.

This study has also considered to what extent the various options would be likely to result in **unintended negative effects**. It concludes that none of the options are likely to lead to increased risks from unsafe and/or counterfeit chargers (although both would be a concern in the event of significantly higher decoupling rates). However, there are economic costs for certain economic operators (most of whom are not based in the EU), some of which are likely to be non-negligible. We also conclude that options 1, 4 and 5 would have a negative effect on innovation, because they would rule out the rapid adoption of any new "game-changing" charging technology in wired mobile phone chargers, thereby reducing the incentives for firms to invest in research and development to seek to gain a competitive advantage, which in turn also risks reducing the pace of "incremental" innovation as regards future generations of "common" (USB) technologies. Nonetheless, the implications of these constraints seem more significant in theory than in practice, in view of the way the market is evolving at present, and companies' own interest in ensuring interoperability.

In summary, the most effective approach to addressing the consumer inconvenience that results from the continued existence of different (albeit mostly interoperable) charging solutions would be to pursue **option 1 (common connectors) in combination with option 4 (interoperable EPS)**. If accompanied by other measures to stimulate decoupling, this could also contribute to achieving the environmental objectives. Introducing such a "common" charger for mobile phones would be likely to also foster its adoption among certain other portable electronic devices, thus generating additional *indirect* consumer (and potentially environmental) benefits. However, whether or not other devices should be encompassed within the scope of the initiative (i.e. the requirement to use the "common" charger be applied to other devices too) needs to be considered carefully. While it appears likely that the benefits would outweigh the costs for certain devices that are broadly similar to mobile phones (in particular tablets), the same is not necessarily the case for other categories of devices that have significantly different uses, functionalities and price ranges (such as many wearables).

In any case, when determining whether or not to pursue this initiative, the question of whether the expected negative economic impacts appear justified by the scale and scope of the social and environmental benefits needs to be given due consideration. The balance would depend partly on the policy instrument used: if the industry was able to make a **voluntary commitment** to implement options 1 and/or 4 (and work with public authorities to explore ways of increasing decoupling rates), this could secure most of the available benefits, while providing enough flexibility to alleviate most of the concerns around unintended negative economic impacts. Should it not be possible to reach a voluntary agreement (as has been the case in the past), **regulation** could provide an alternative solution. However, as noted above, there are important trade-offs and risks to consider, as well as question marks about the legal basis for a regulatory proposal (depending on its exact scope).

ANNEXES

Annex A: Glossary

Term	Definition
Alternating Current (AC)	AC is an electric current which periodically reverses direction, in contrast to direct current (DC) which flows only in one direction. Alternating current is the form in which electric power is delivered to businesses and residences, and it is the form of electrical energy that consumers typically use when they plug appliances into a wall socket.
Consumer panel	Group of individuals selected by a business or organization to provide input and opinion on products and services for research on consumer behaviour. Panel members are chosen to be representative of the general population or a target group.
Counterfeit charger	Counterfeit chargers (external power supplies and/or connector cables) are chargers infringing intellectual property right(s), such as trademark, patent and design. They have a reputation for being lower quality (e.g. they can damage batteries). They frequently do not fulfil safety requirements, thus posing risks to consumer safety (e.g. risk of causing electrocution, starting a fire).
Decoupling	Sale of mobile phones without including a charger
External Power Supply (EPS)	Device which meets all of the following criteria, as per Regulation 278/2009 on ecodesign: (a) it is designed to convert alternating current (AC) power input from the mains power source input into lower voltage direct current (DC) or AC output; (b) it is able to convert to only one DC or AC output voltage at a time; (c) it is intended to be used with a separate device that constitutes the primary load; (d) it is contained in a physical enclosure separate from the device that constitutes the primary load; (e) it is connected to the device that constitutes the primary load via a removable or hard-wired male/- female electrical connection, cable, cord or other wiring; (f) it has nameplate output power not exceeding 250 Watts; (g) it is intended for use with electrical and electronic household and office equipment as referred to in Article 2(1) of Regulation (EC) No 1275/2008.
High-end phones	Phones that are amongst the most expensive or advanced in a company's product range, or in the market as a whole.
In-the-box charger	Chargers that are sold together with the mobile phone, when consumers buy a new phone.
Lightning	Proprietary computer bus and power connector created by Apple Inc. It was introduced on September 2012 to replace its predecessor, the 30-pin dock connector. The Lightning connector is used to connect Apple mobile devices like iPhones, iPads, and iPods to host computers, external monitors, cameras, external power supplies, and other peripherals. Using 8 pins instead of 30, Lightning is significantly more compact than the 30-pin dock connector and can be inserted with either side facing up. However, unless used with an adapter, it is incompatible with cables and peripherals designed for its predecessor.
Low-end phones	Phones that are amongst the cheapest in a company's product range, or in the market as a whole.
Low Voltage Directive (LVD)	Directive of the European Parliament and of the Council on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment. The LVD focuses on health and safety risks, and applies to a wide range of equipment designed for use within certain voltage limits, including power supply units.
Memorandum of Understanding (MoU)	Nonbinding agreement between two or more parties outlining the terms and details of an understanding, including each parties' requirements and responsibilities. It expresses a convergence of will between the parties, indicating an intended common line of action.

Term	Definition
Mobile phone	Battery-powered handheld communication device of which the primary purpose is voice telephony, which operates on public cellular networks, which potentially supports other services and which is designed to be hand-portable.
Radio Equipment Directive	The Radio Equipment Directive 2014/53/EU (RED) establishes a regulatory framework for placing radio equipment on the market. It ensures a Single Market for radio equipment by setting essential requirements for safety and health, electromagnetic compatibility, and the efficient use of the radio spectrum. It also provides the basis for further regulation governing some additional aspects. These include technical features for the protection of privacy, personal data and against fraud. Furthermore, additional aspects cover interoperability, access to emergency services, and compliance regarding the combination of radio equipment and software.
PMA	Power Matters Alliance (PMA) was a global, not-for-profit, industry organization whose mission was to advance a suite of standards and protocols for wireless power transfer. The organization was merged with Alliance for Wireless Power (A4WP) in 2015 to form AirFuel Allliance.
Preferred Charging Rate	Concept introduced in the MoU signed in 2008. It was defined as charging a battery from 10% capacity to 90% capacity within a maximum of 6 hours.
Proprietary charging solution	Charging solution owned by a single organization or individual. Ownership by a single organization gives the owner the ability to place restrictions on the use of the solution and to change it unilaterally. Specifications for proprietary solutions may or may not be published, and implementations are not freely distributed.
Qi	Open interface standard that defines wireless power transfer using inductive charging over distances of up to 4 cm, and is developed by the Wireless Power Consortium. The system uses a charging pad and a compatible device, which is placed on top of the pad, charging via resonant inductive coupling. The Wireless Power Consortium (WPC) is a multinational technology consortium formed in December 2008. Its mission is to create and promote wide market adoption of its interface standard Qi. It is an open membership of Asian, European, and American companies, working toward the global standardization of wireless charging technology.
Quick Charge	Quick Charge is a Qualcomm's proprietary technology which allows for the charging of battery powered devices, primarily mobile phones, at levels above and beyond the typical 5 volts and 2 amps for which most USB standards allow. To take advantage of Qualcomm Quick Charge, both the external power supply and the device must support it.
Standalone charger	External power supplies sold on their own, without being part of a full package including a phone (or another device) and the charger
Universal Serial Bus (USB)	USB is an industry standard that establishes specifications for cables, connectors and protocols for connection, communication and power supply between personal computers and their peripheral devices, or between a device and the external power supply. Released in 1996, the USB standard is currently maintained by the USB Implementers Forum (USB IF).
USB-IF	The non-profit USB Implementers Forum, Inc. was formed to provide a support organization and forum for the advancement and adoption of USB technology as defined in the USB specifications. The USB-IF facilitates the development of high-quality compatible USB devices through its logo and compliance program, and promotes the benefits of USB and the quality of products that have passed compliance testing.
USB micro-B	Connector (B-Plug and B-Receptacle) which can be used for charging support and additional functions, whose reference specification is “Universal Serial Bus Cables and Connector Class Document” Revision 2.0 August 2007, by the USB Implementers Forum.

Term	Definition
USB Type C	24-pin USB connector system, which is distinguished by its two-fold rotationally-symmetrical connector. A device with a Type-C connector does not necessarily implement USB 3.1, USB Power Delivery, or any Alternate Mode: The Type-C connector is common to several technologies while mandating only a few of them.
USB 3.1	USB 3.1, released in July 2013, is the successor standard that replaces the USB 3.0 standard. USB 3.1 preserves the existing SuperSpeed transfer rate, giving it the new label USB 3.1 Gen 1, while defining a new SuperSpeed+ transfer mode, called USB 3.1 Gen 2 which can transfer data at up to 10 Gbit/s over the existing USB-type-A and USB-C connectors (1250 MB/s, twice the rate of USB 3.0)
USB 3.2	USB 3.2, released in September 2017, replaces the USB 3.1 standard. It preserves existing USB 3.1 SuperSpeed and SuperSpeed+ data modes and introduces two new SuperSpeed+ transfer modes over the USB-C connector using two-lane operation, with data rates of 10 and 20 Gbit/s (1250 and 2500 MB/s).
USB Power Delivery	In July 2012, USB-IF announced the finalization of the USB Power Delivery (PD) specification (USB PD rev. 1), an extension that specifies using certified PD aware USB cables with standard USB Type-A and Type-B connectors to deliver increased power (more than 7.5 W) to devices with larger power demand. The USB Power Delivery specification revision 2.0 (USB PD rev. 2) was released as part of the USB 3.1 suite. It covers the Type-C cable and connector with four power/ground pairs and a separate configuration channel. Revision 3.0 was released in 2017.
USB Fast Chargers	Certified USB Fast Chargers support the Programmable Power Supply (PPS) feature of the USB Power Delivery 3.0 specification. New USB hosts, devices and chargers supporting PPS are required for users to take full advantage of this feature. Certified USB Fast Chargers are backwards compatible with devices that support USB Type-C™ and USB Power Delivery.
WEEE	Waste of electrical and electronic equipment (WEEE) such as computers, TV-sets, fridges and cell phones, which is the subject of Directive 2012/19/EU.
Wireless charging	Inductive charging (also known as wireless charging or cordless charging) uses an electromagnetic field to transfer energy between two objects through electromagnetic induction. This is usually done with a charging station. Energy is sent through an inductive coupling to an electrical device, which can then use that energy to charge batteries or run the device.
30-pin connector	Apple's proprietary connector, common to most Apple mobile devices (iPhone (1st generation), iPhone 3G, iPhone 3GS, iPhone 4, iPhone 4S, 1st through 4th generation iPod Touch, iPad, iPad 2, and iPad 3) from its introduction with the 3rd generation iPod classic in 2003 until the Lightning connector was released in late 2012.

Annex B: Public consultation synopsis report

The online Public Consultation on standard chargers for mobile phones was launched by the European Commission on 14 May 2019 and closed on 6 August 2019. In total, 2,850 responses were received.

The Public Consultation was part of a broader evaluation of potential policy interventions aimed at assessing the opportunity to mandate a common charger for mobile phones across the European Union. This survey sought to gather opinions and evidence on the current situation for chargers for mobile phones and other battery-powered devices.

A variety of private and public stakeholders were invited to take part in the Public Consultation. The vast majority of responses (2,743 entries) came from EU citizens.

The Public Consultation showed generalised support among respondents for the standardisation of mobile phones chargers, and possibly extending standardisation to other battery-powered devices. Approval for standardisation was normally higher among citizens compared to industry stakeholders, although common concerns to both groups were innovation and electronic waste. Consumers also highlighted that financial costs and performance issues arose as a consequence of the variety of chargers in circulation. Both consumers and manufacturers were in favour of harmonisation, although citizens more consistently supported regulatory intervention. The views of NGOs, consumer associations, research institutions, and public authorities tended to be in line with those of individual citizens.

Methodology

The online consultation was open to everyone who wished to contribute on the topic of standard chargers for mobile phones. It aimed to reach as many respondents as possible and for this reason it had a stated target audience of a wide array of stakeholders, including, but not limited to, consumers and consumer associations, economic operators potentially affected by regulatory action, Member States' authorities, Market Surveillance Authorities for the Low Voltage Directive 2014/35/EU and Radio Equipment Directive 2014/53/EU, and the European Standardisation organisations. As part of a set of preliminary questions, respondents were asked to indicate the capacity in which they were answering.

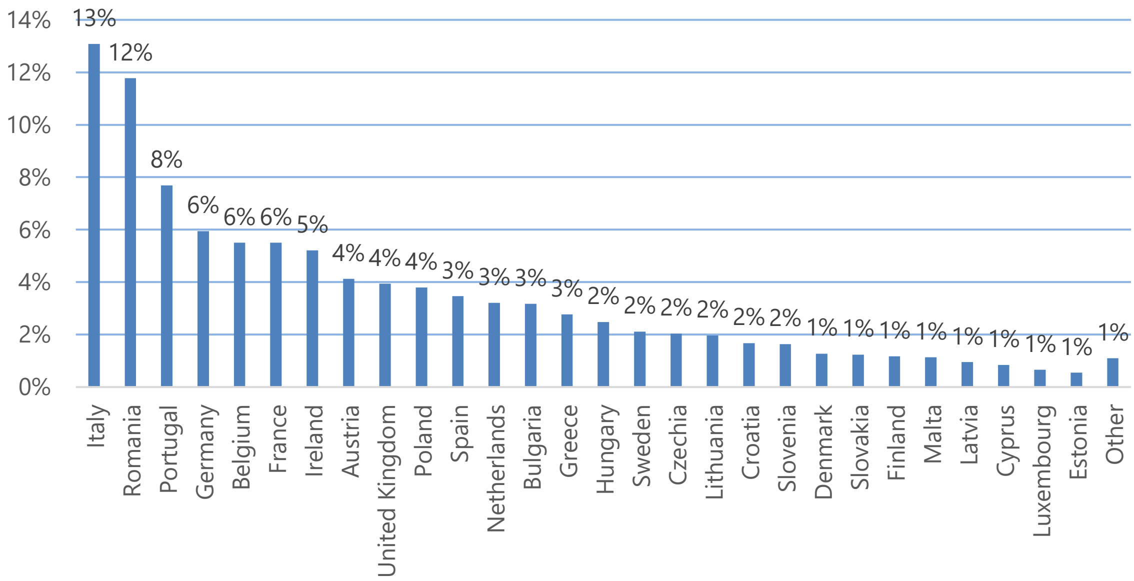
The Public Consultation comprised 10 sections of mandatory questions, and additional questions that were based on previous responses. Optional open-ended questions allowed respondents to further elaborate on each section.

The survey was mainly promoted through social media channels. In light of the way it was made available and circulated, caution should be exercised when interpreting its results due to the likely presence of selection bias. In other words, the respondents that took part in this survey do not form a representative sample but are likely to be those with a strong interest in the topic (and/or a particular policy response).

Overview of the respondents

The Public Consultation achieved a total of 2,850 respondents. An overwhelming majority were EU citizens (2,743, or 96%). Non-EU citizens accounted for 34 entries, resulting in a total of 2,777 responses from private individuals (97%).

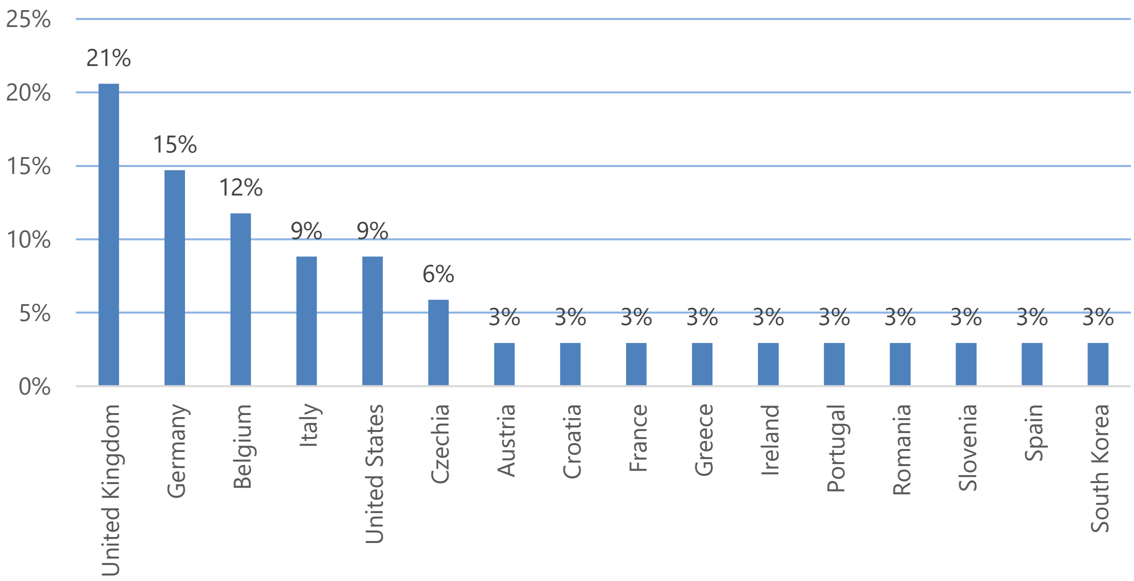
Figure 31: EU citizens by country of origin



Source: *Public Consultation (2019). N=2,743*

There were responses from citizens from all EU countries. Among the countries with the highest number of respondents were Italy (13%), followed by Romania (12%), and Portugal (8%).

Figure 32: Businesses and business associations by country of origin



Source: *Public Consultation (2019). N=34*

34 companies, business organisations, and business associations[100] that participated in the Public Consultation were mainly based in EU countries. 7 (21%) were from the UK, 5 (15%) from Germany, and 4 (12%) from Belgium. Responses were received also

[100] Companies, business organisations and business associations are often referred to as 'businesses and business organisations', 'the business sector' or 'the business sector' throughout the report. 'The industry' are instead those directly involved in the production or trading of mobile phones or chargers.

from companies based in Korea (1) and in the United States (3). Of the companies, 42% were from sectors that clearly have a direct stake in the initiative (including mobile phone manufacturers and other technology firms), whilst 13% were telecommunications companies, two testing bodies, and one represented a certification body. The remainder came from a variety of other sectors, including human resources, training providers, and the retail sector.

19 individuals representing public authorities submitted their views. Of these, five stated that their authorities had an international scope, 12 a national dimension, and the rest a regional competence.

Fewer responses were received from NGOs, consumer organisations, and academic institutions – overall reaching 14 contributions. The three participating consumer organisations were from Belgium, Iceland, and Italy, whilst two NGOs were from Belgium, one from Bulgaria, and one from Switzerland. Among the NGOs that took part in the Public Consultation, only one had a clear environmental focus.

Knowledge of the current situation

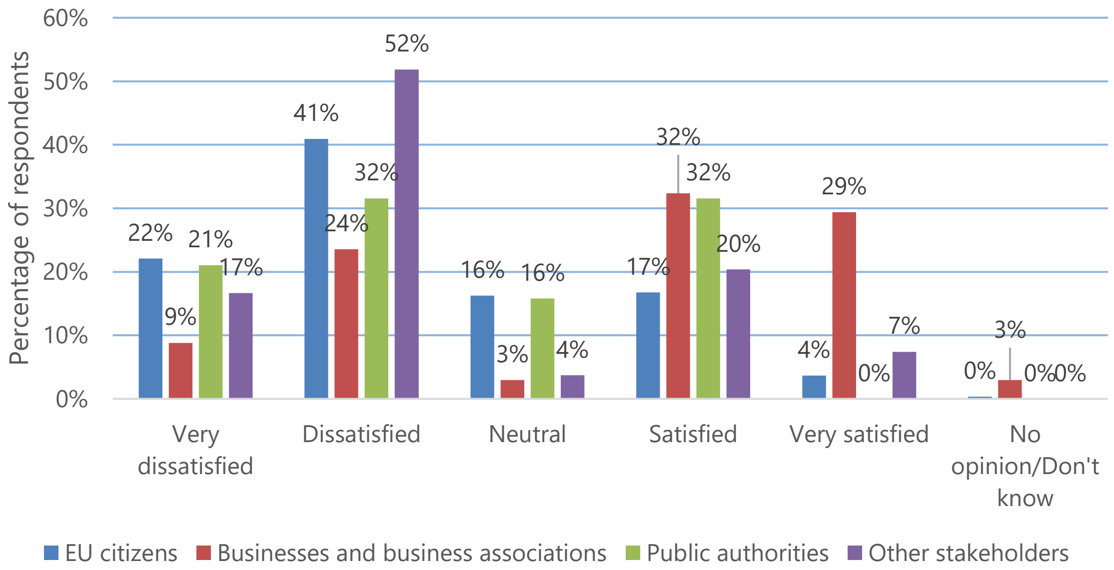
Mobile phones

Respondents were asked to describe the situation regarding the number of mobile phone chargers available on the market. 68% of all respondents believed that there were a few different types of chargers on the market; 32% indicated that there are many different types of chargers. Less than 1% considered that only one type of charger existed.

Just over half of the respondents (51%) considered that external power supplies (EPSs) could be used with most phones, providing that they were used with the right cable, while 30% mentioned that both cable and EPS can be used with most phones. 14% indicated that it is normally difficult to interchangeably use chargers, while 4% deemed it possible to use the cable, but not the EPS, to charge other mobile phones.

63% of EU citizens declared that they feel 'dissatisfied' (41%) or 'very dissatisfied' (22%) with the present situation, with only 17% stating that they are 'satisfied' or 4% 'very satisfied'. A neutral opinion was expressed by 16% of respondents. Figures from businesses and business associations are markedly different, with 62% of satisfaction and 32% of dissatisfaction, and only 3% of neutral opinions.

Figure 33: Are you satisfied with the current situation regarding mobile phone chargers and their seamless interconnection?



Source: *Public Consultation (2019). N=2,850*

In open-ended answers, whilst consumers tended to highlight a variety of drawbacks related to the absence of a common standard solutions, ranging from environmental issues to financial aspects, businesses and business organisations underlined the progress made following the two Memoranda of Understanding (MoU), as well as the recent consensus achieved over the promotion of USB Type C as the new charging standard. The views of public authorities were varied, with certain respondents stressing the inconvenience caused by the existence of multiple types of connectors, while others underlined how progress had been made thanks to industry-wide agreements. However, certain public authorities' representatives suggested that there could be room for improvement of standardisation, as having multiple chargers is also a problem in terms of e-waste.

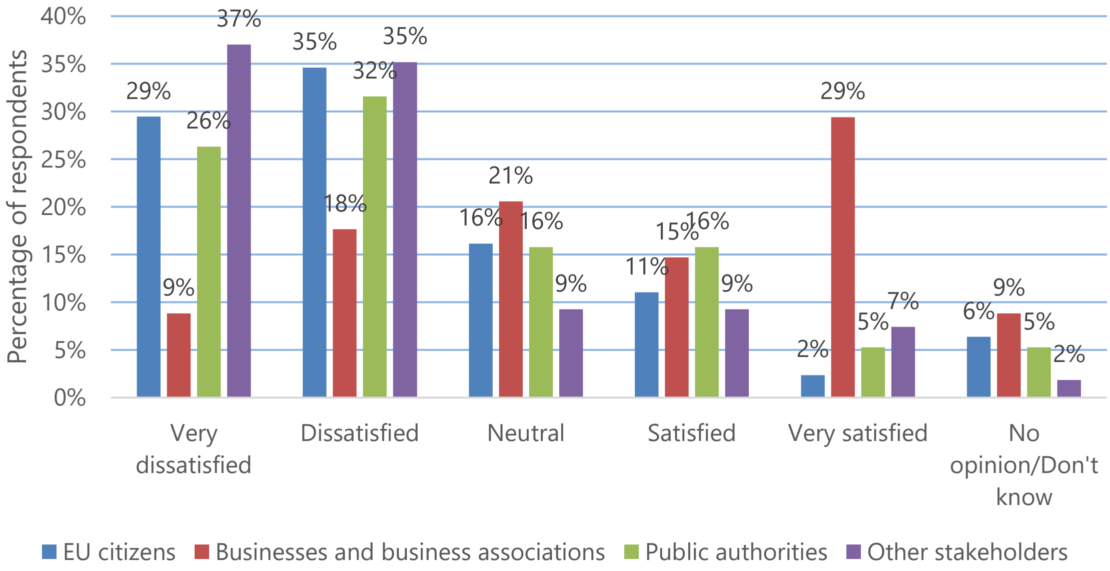
Other devices

When asked about the situation related to the number of chargers for other devices, 56% of all respondents indicated that there are many different types of chargers, whilst 36% noted that there are a few types in circulation. 1% considered that there was only one type of charger, whilst 6% were unable to provide an answer.

38% of respondents deemed it impossible to use chargers to charge different electronic devices, whilst 33% indicated that it is possible to make use of the EPS, but not of the cable, to charge other devices. The possibility of using the whole charger with other devices was indicated by 18% of respondents, while 4% indicated that the cable, but not the EPS, could be used with other devices. Nearly 8% had no opinion or did not know the answer.

The percentage of respondents dissatisfied with this situation was 34%, whilst 29% declared to be very dissatisfied. 11% of respondents were satisfied, and 3% very satisfied. 16% held neutral views.

Figure 34: Are you satisfied with the current situation regarding chargers for portable electronic devices other than mobile phones and their seamless interconnection?



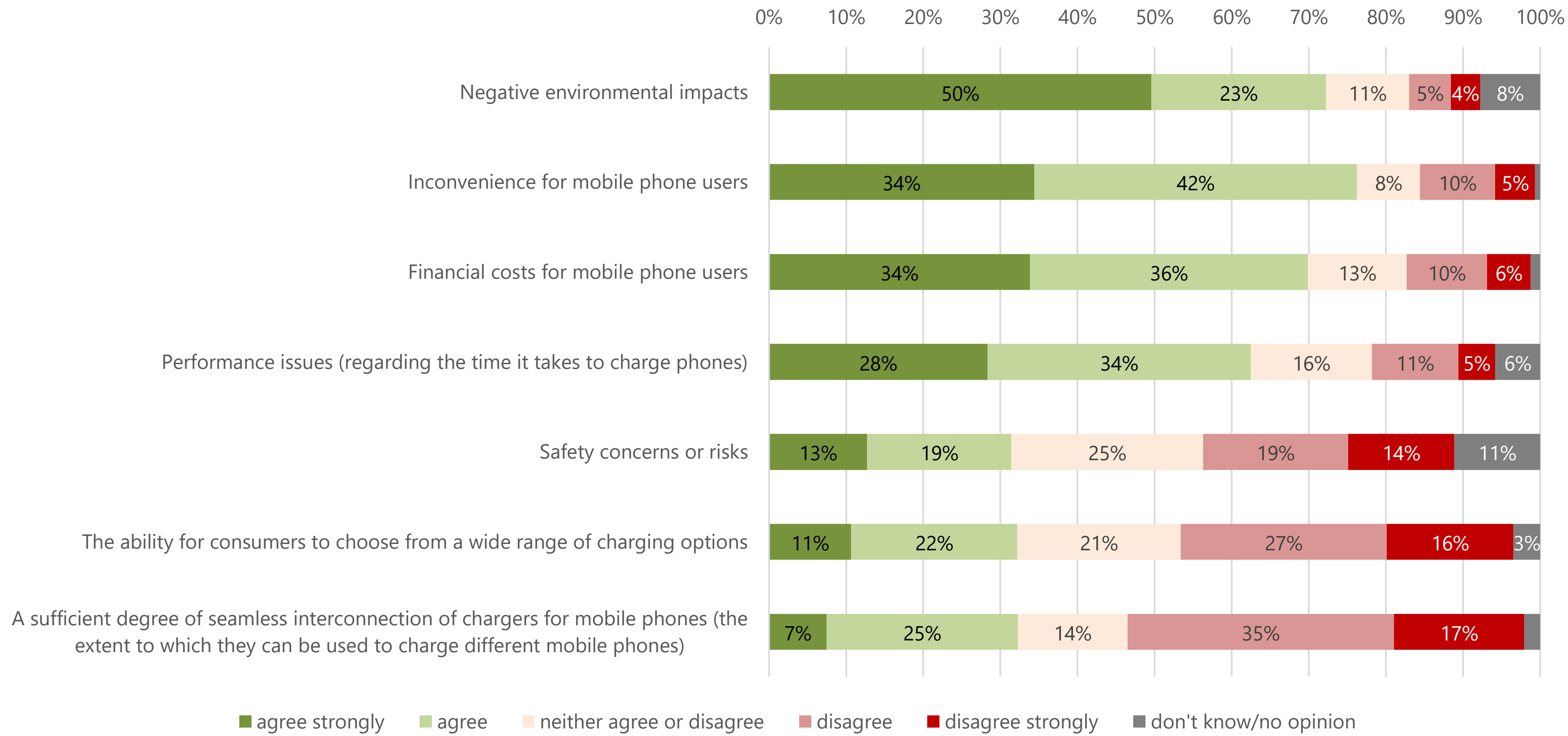
Source: *Public Consultation (2019). N=2,850*

Some consumers highlighted that different charging solutions might be needed for different devices as a result of diverging technical requirements. NGOs considered that the variety of chargers present on the market is a source of difficulties for the visually impaired and the disabled. Public authorities stressed that certain devices were increasingly sold without chargers, and that improvements were taking place as there was a pattern of convergence towards USB Type C. However, some stakeholders from public authorities suggested that having different types of chargers for different phones was a source of inconvenience especially when travelling.

Problems experienced

The Public Consultation sought to establish which problems – if any – respondents experienced as a result of the situation relating to chargers. At times, divergent views were expressed by consumers, consumer associations, public authorities, and NGOs on one side, and business stakeholders on the other.

Figure 35: Do you agree that the current situation regarding chargers for mobile phones results in:



Source: *Public Consultation (2019). N=2,743.* ***Note:*** *Only EU citizens.*

- A clear majority of EU citizens indicated that the present situation was a source of inconvenience. Respectively, 42% and 34% respectively agreed or strongly agreed with this statement. Only 10% disagreed and 5% strongly disagreed with the statement. 8% held neutral views.

- Half of EU citizens strongly agreed that a clear environmental impact arose from the situation and 23% agreed with this. 11% was of a neutral opinion, and only 9% considered that there was no environmental impact (5% disagreed and 4% strongly disagreed).

- EU citizens indicated that having multiple types of chargers caused performance issues (28% strongly agreed and 34% agreed). 16% expressed neutral views, 11% disagreed and 5% strongly disagreed.

- Most EU citizens indicated that the situation resulted in a financial burden for mobile phone users: 36% agreed and 34% strongly agreed with this statement. 13% did not have a clear opinion on the matter, whilst 10% disagreed and 6% strongly disagreed with the fact that the situation resulted in financial costs.

- Safety hazards were linked to the presence of multiple types of chargers for 32% of EU citizens (13% strongly agreed, 19% agreed). Similar percentages disagreed and strongly disagreed (19% and 14% respectively), although 1 in 4 EU citizens had a neutral opinion on the topic.

- Only 33% of EU citizens saw the situation as beneficial in terms of variety of choice (11% strongly agreed, 22% agreed). 41% did not consider the situation to be beneficial (21% disagreed and 27% strongly disagreed). However, 22% held neutral views.

- 25% of EU citizens strongly agreed with the statement that chargers presented a seamless degree of interconnection, while 7% strongly agreed. However, 14% held a neutral opinion, and the majority disagreed (with 34% disagreeing and 17% strongly disagreeing).

EU citizens' views are aligned with those expressed by NGOs and consumer organisations. Public authorities had more nuanced views, although generally aligned with consumers in indicating financial costs and environmental reasons as the two single-largest problems. Businesses' and business organisations' opinions sometimes showed notable differences from consumers' views in terms of environmental impact (30% held that there was no environmental impact) and inconvenience (47% indicating that no inconvenience was caused by having multiple types of chargers). In addition to this, variety was seen by 56% of businesses and business organisations as a positive factor.

Inconvenience

The views of those who responded that the present situation generates inconvenience (N=2,161, or 76% of all respondents) were further analysed with an additional set of questions.

Among those who indicated that the situation resulted in inconvenience, the following were the main sources of inconvenience reported by respondents:

- 73% of EU citizens believed the fact that users of different electronic devices (including but not limited to mobile phones) need to have multiple chargers which occupy space and may lead to confusion to be a serious problem, while 26% of respondents described this as a minor problem. Only 1% of respondents did not consider it a problem.

- EU citizens also indicated that it can be difficult to find a suitable charger when away from home, with 64% considering this a serious problem and 35% a minor issue.
- Having multiple chargers taking up space or generating confusion in the household was considered a serious problem by 58% of respondents, while 39% considered this a minor problem. This was not deemed an issue by only 2% of respondents.

The views of those businesses and business organisation that reported inconvenience were aligned with those of consumers, although not having a suitable charger when travelling was indicated as a serious problem only by 54% of the business stakeholders in the subsample.

Environment

Environmental concerns (N=2054, or 72%) were further analysed.

- Those EU citizens concerned by the environmental impact of multiple types of chargers indicated as a serious problem the fact that old chargers may not be properly recycled or reused (91%), while 8% only considered this a minor issue.
- The amount of e-waste generated by old chargers was a serious concern for 93% of respondents and a minor problem for 6%.
- The depleting of natural resources and increasing gas emissions linked to the production of chargers is highlighted as a serious problem by 86% of respondents, whilst it is considered a minor issue by 12% of respondents.

When considering businesses' opinions, percentages are generally lower. 56% considered accumulating chargers at home or not recycling them as a serious issue (33% as a minor issue). 67% was seriously concerned by the consumption of scarce resources and CO2 emissions resulting from the manufacturing process (28% indicated this as a minor problem). E-waste was instead a serious concern for 67% of businesses and business organisations, and a minor problem for 28% of them.

Performance

The views of those respondents who had highlighted that a situation in which multiple types of chargers are present causes performance issues (N=1773, or 62%) were further analysed.

- Longer charging time for a fast-charging enabled phone charged with a different charger were a serious problem for 57% of EU citizens, a minor problem for 37%, and for 3% it was not a problem.
- The fact that, as a result of this situation, mobile phones take too long to charge was indicated as a serious problem by half of the EU citizens who had indicated safety as a problem, while 46% considered it a minor problem. 4% did not feel that this was a problem.

Although performance issues are perceived as a problem also by the business sector, less than half of businesses and business organisations consider that having multiple chargers has serious consequences for performance.

Financial costs

When restricting the sample to consider the views of those reporting that having multiple types of chargers generates financial costs (N=1476, or 52%), the following results were found:

- Needing to buy a replacement charger when one breaks rather than re-using one was a serious problem for 75% of the EU citizens in the subsample, and for 22% it was a minor issue. For 3% it was not a problem.

- 39% of the EU citizens indicated as a serious problem the fact that new phones are sold with a new charger, resulting in a price increase. However, 45% considered that this was a minor problem, while for 15% this did not present any problems.

Business stakeholders were divided on whether the current situation increases the costs which consumers have to bear, while noting that financial costs are generally a minor problem as chargers are usually affordable.

Safety

Narrowing the sample to those who judged that the situation posed a safety hazard (N=899, or 32%), a clear majority of EU citizens indicated that unbranded chargers or chargers not specifically designed for the mobile phone in use may be potentially unsafe. The results showed that:

- Safety concerns were also caused by the presence of many counterfeit chargers on the market. Most EU citizens (80%) among those who had indicated safety-related problems suggested that this was a serious problem, and 16% that it was a minor issue. 2% did not report the presence of counterfeit chargers as a problem.

- Safety was a serious concern for 72% of EU citizens, while it was a minor problem for 21% of them. Only 5% did not consider this an issue.

However, business stakeholders appeared more likely to indicate the presence of counterfeit chargers as a serious problem compared to EU citizens (90% vs 80% respectively).

In their open-ended comments, European citizens appear particularly concerned about the impact of counterfeit or unsafe chargers on devices (e.g. in terms of battery life). Similar views were expressed by public authorities, concerned with limitations to interoperability.

The competitiveness of the market for chargers is stressed by the business sector; yet, business stakeholders also underlined that sub-standard chargers are potentially unsafe for users. Following these considerations, business stakeholders questioned whether a single charger type would increase hazards by indirectly favouring the commercialisation of counterfeit or sub-standard charging solutions.

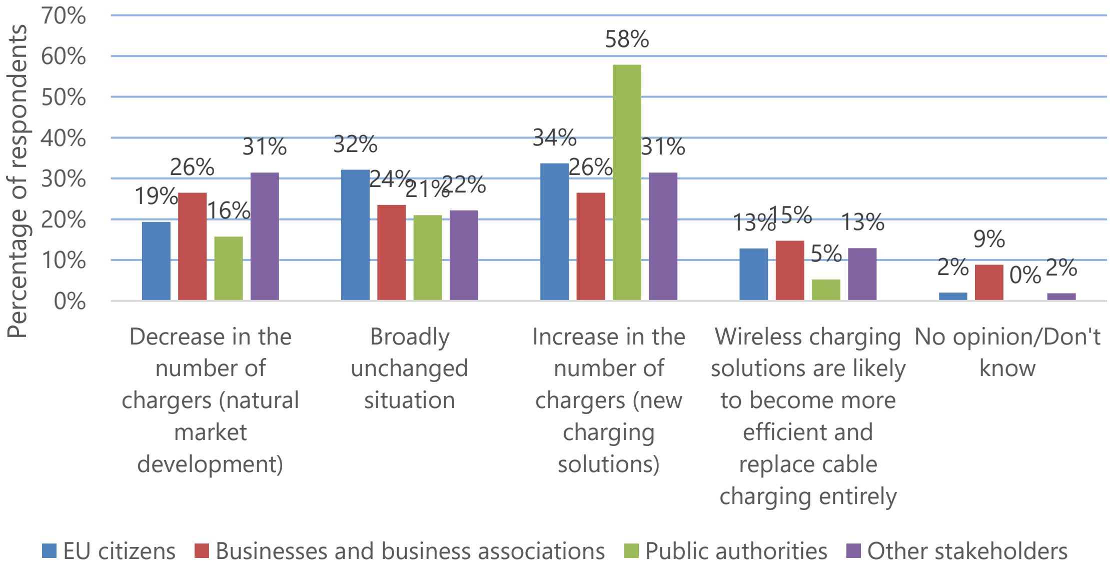
<u>Expected situation in the next 5-10 years</u>

EU citizens are divided on the future of mobile phone chargers, should the EU refrain from acting. 32% believed that the situation would remain broadly unchanged, whilst 34% expected the number of chargers on the market to increase due to the introduction of new charging solutions. However, 19% foresaw a natural convergence of the types of chargers available that would lead to a reduction in the number of chargers available. 13% indicated wireless charging as the standard which would entirely replace other charging standards.

Consumer associations and NGOs held stronger views relative to the fact that the number of types of chargers is set to increase (63%), while 25% expected a downward trend. 13% indicated that the situation would remain the same. Public authorities were strongly (58%) of the opinion that the number of different types of chargers would increase without any standardisation measure.

Differences are marked when considering businesses' and business organisations' opinions. An equal share of stakeholders (26%) considered that the number of chargers could either increase or decrease. 24%, instead, predicted that the situation would be broadly unchanged, while for 15% wireless charging would replace cable charging entirely.

Figure 36: Do you think the situation would change in the next 5-10 years if the EU takes no action?



Source: *Public Consultation (2019). N=2,850*

<u>Should the EU take further action for mobile phones chargers?</u>

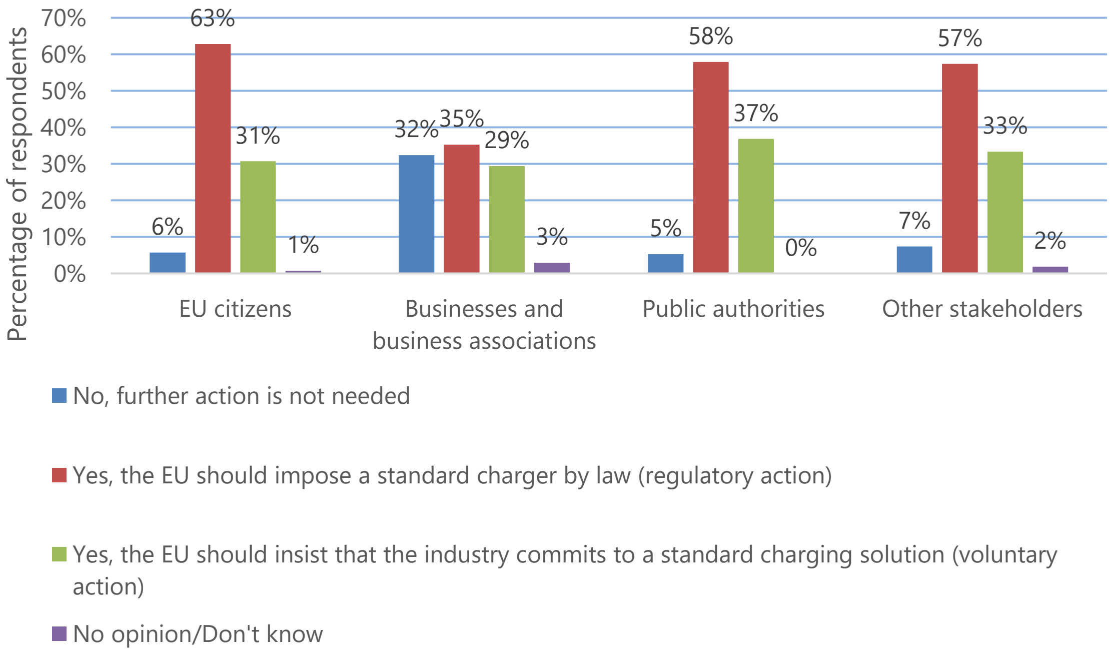
Respondents were then asked whether they consider action by the European Union necessary to change the current situation.

There seems to be strong consensus among EU citizens on the need for a common charger model. A 63% majority was in favour of the European Union exercising its regulatory power to mandate a charger standard, whilst 31% considered that the EU should promote an industry-wide agreement. Only 6% of EU citizens suggested that the EU should abstain from any form of intervention. Support for a common charging solution was also expressed by public authorities, non-governmental organisations, and consumer organisations in similar proportions.

Among the industry sector, 35% deemed regulatory action necessary, while 29% would opt for an industry-led agreement. Yet, 32% opposed further action.

All NGOs, public authorities, and consumer associations are in favour of further action. A large majority (75%) leaned towards regulatory intervention, while 1 in 4 recommended an industry-led agreement.

Figure 37: Should the EU should take further action to create a standard charger for mobile phones?

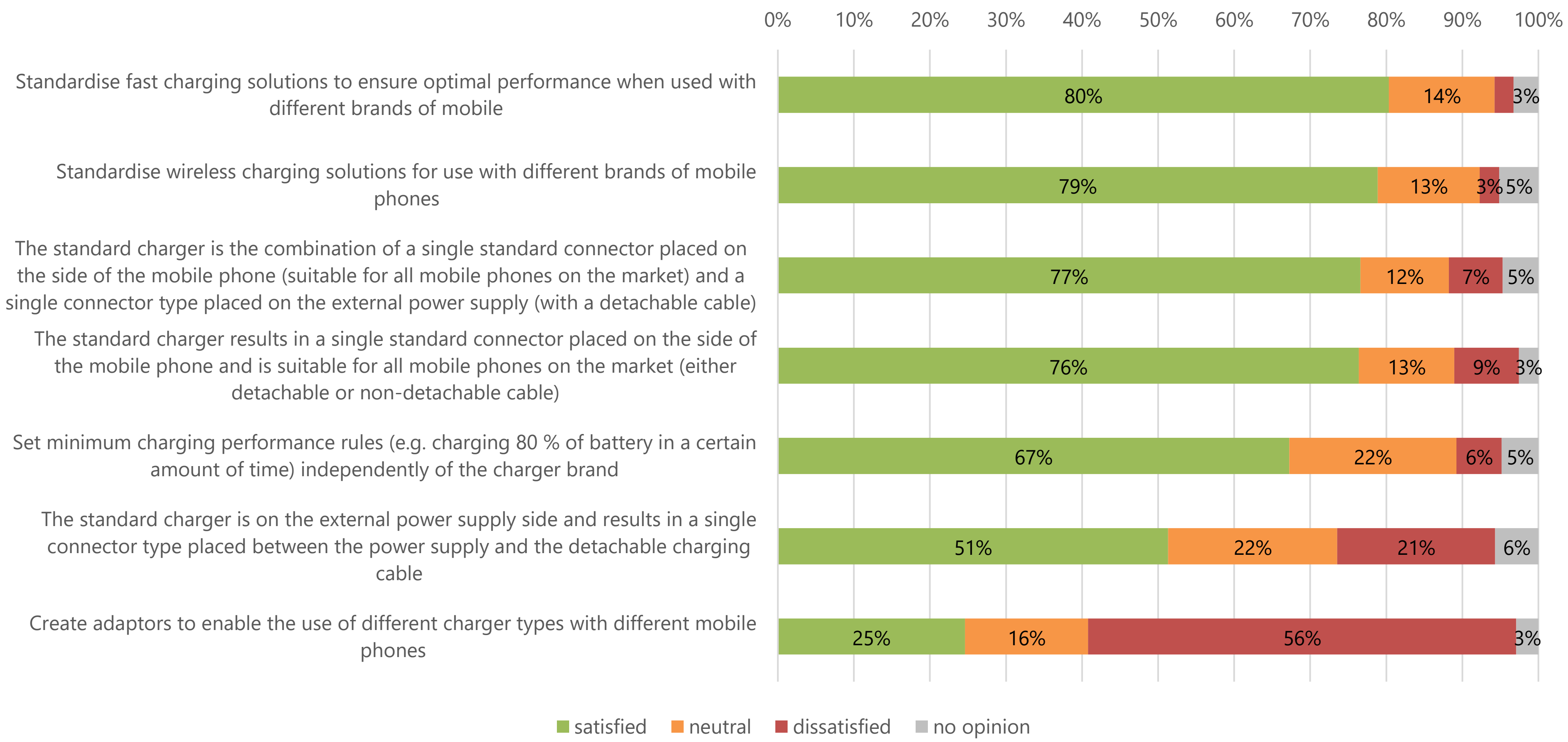


Source: *Public Consultation (2019). N=2,850*

Preferences for a standard charging solution

The view of those respondents who expressed support for an EU intervention to standardise chargers (N=2,653, or 93%) were further investigated.

Figure 38: If you responded that the EU should take further action to create a standard charger for mobile phones, would you be satisfied with the following solutions for standard mobile phone chargers?



Source: *Public Consultation (2019). N=2,564.* ***Note:*** *Only EU citizens.*

- The standardisation of fast-charging solutions found broad consensus among EU citizens (80% would be satisfied with this solution). Neutral views were expressed by 14% of EU citizens, while 3% would be dissatisfied by this measure.

- Similar percentages were recorded for the standardisation of wireless charging solutions (79% satisfied, 13% neutral, and 3% dissatisfied).

- The standardisation of the whole charger would be the preferred option for 77% of EU citizens, whilst 12% have no clear view and 7% would be against it. Similar views are expressed in the case of the imposition of a standard only for the cable on the device side.

- Setting minimum charging performance rules would be the preferred option of 67% of EU citizens in favour of further action, 22% indicated a neutral opinion, and only 6% would be dissatisfied.

- More mixed views are expressed by consumers when considering standardisation only on the EPS side. 52% of EU citizens would endorse this solution, although 21% would be dissatisfied. A neutral opinion was held by 22% of citizens. Standardising only the connector on the phone side saw 76% of EU citizens satisfied, 13% with neutral opinions, and 8% dissatisfied.

- EU citizens in favour of further action would generally be dissatisfied with the creation of adaptors to ensure interoperability among chargers. Only 25% would be satisfied with the introduction of adaptors, whilst 56% would consider this option dissatisfying. 16% recorded a neutral opinion.

There is broad support among business stakeholders for the standardisation of wireless chargers (77%) and fast-charging chargers (73%); consensus for alternative forms of standardisation is slightly lower. Within the business sector, only 22% agree that adaptors could be an option.

<u>Other devices that could be standardised</u>

88% of EU citizens indicate a preference that tablets could also be standardised. A high share of European citizens also supports the standardisation of chargers for cameras (73%), laptops (74%), e-readers (76%), and smartwatches (70%). Harmonisation for chargers of other devices, such as GPS navigation systems and battery-powered household appliances, is desirable for 65% and 60 of EU citizens respectively. Battery toys chargers should be harmonised for 51% of EU citizens. An even stronger endorsement for standardisation came from NGOs and consumer associations. Public authorities hold stronger views compared to consumers on the need for standardisation of other devices apart from toys and household appliances.

The business sector was generally more cautious about the standardisation of other devices. Only tablets seem to aggregate broad consensus (68%), with all other items being below 50% of support (household appliances at 32%, being the item which received the lowest share of agreement).

A pattern seems to emerge from some consumer opinions that different standards could be set for different device types, in consideration of their different power requirements. As some consumers appear to suggest, a certain degree of flexibility should be allowed to encourage innovation. Consumers also indicated headphones, gaming consoles, and electric vehicles as other potential areas for standardisation.

Business stakeholders highlighted that one option could be to devise EPSs that could adapt to the power requirements of the device they are charging or to create clearly identifiable categories of chargers. Public authorities, in open-ended comments, suggested that a rule for standardisation could be to impose bands based on product requirements – i.e. standardising chargers for devices with similar technical requirements.

Foreseeable impacts of EU action

According to EU citizens, there would be many gains from the introduction of a standardisation solution.

- Most citizens mentioned convenience for consumers; 83% believed the impact would likely be positive, 8% possibly positive, and only 2% likely negative or possibly negative.

- The second most likely positive impact would be on the reduction of e-waste (73% considered it likely positive, 15% possibly positive, 2% possibly negative, and 4% likely negative).

- Another likely positive impact would be on financial costs (likely to decrease for 70% of EU citizens, possibly decreasing for 18%, possibly not decreasing for 3%, and not decreasing for 4%).

- Enhanced conservation of natural resources would be a likely positive outcome for 67% of EU citizens, possible for 18%, possibly negative 2%, and likely negative for 3%.

- Consumer choice would be likely be impacted positively for 66% of EU citizens, possibly positively for 19%, possibly negatively for 4%, and likely negatively for 5%.

- 64% believed that standardisation was likely to result in improved safety (64% likely, 18% possible, whilst 2% and 1% respectively judged the impact possibly negative or likely negative).

- Reduced CO_2 emissions were likely to be impacted upon positively for 63% of EU citizens, possibly positively for 17%, possibly negatively impact for 2%, and a likely negatively impact for 3%.

- A positive impact was believed to be less likely on the competitiveness of EU industry (40% judged it likely, and was possible for 28% of EU citizens, while it was indicated as possible negative by 6% and likely negative by 7% of EU citizens.

- Expected impact on profitability of mobile phone manufacturers were likely positive for 31% of EU citizens, possibly positive for 30%, possibly negative for 10%, and likely negative for 11%.

- Impacts on curbing counterfeiting were likely positive for 30%, possible positive for 14%, possible negative for 12%, and likely negative for 18% of EU citizens.

- The impact on profitability of charger producers was deemed likely positive for 27%, possible for 26%, possible negative for 12%, and likely negative for 20%.

However, when considering impacts on the industry, uncertainty in responses among EU citizens is generally high (between 13% and 25% depending on the type of impact).

Businesses and business organisations were generally more cautious in judging potential impacts as positive. Particularly business stakeholders highlighted negative impacts in terms of safety (32% suggesting that the effects would be likely negative), or in terms of counterfeit chargers in circulation (29% indicating effects as likely negative). Alongside indicating likely negative effects on profitability for charger manufacturers and phone producers (18% and 29% respectively), 41% of businesses and business organisations also expected likely negative impacts on innovation.

In open-ended comments, the industry highlighted the potential consequences of standardisation in terms of international trade hindrance, and the resulting disadvantage that could affect European consumers. They expressed concern for reduced choice for EU citizens, whilst also warning against the risk that, with a mandated solution, chargers should be larger in size in order to ensure interoperability. Industry stakeholders also highlighted the potential negative impact on SMEs.

Information on identified campaigns

Five contributions among those submitted by business associations appear to be similar and based on a common script. The main themes that were highlighted in the case of the proposed standardisation of mobile phone chargers were:

- The fact that in 2013, by virtue of the MoU, standardisation had been achieved for over 90% of all handsets sold in the EU;
- The industry is naturally switching to USB Type C as a standard;
- A natural transition avoids unnecessary e-waste and is convenient for consumers;
- The transition will be completed by February 2019;
- Micro-USB remains a viable solution for low-end devices.

Relative to other devices, the main considerations submitted were:

- There is a new MoU in place as of March 2018 for convergence towards USB Type C;
- New technologies are capable to adjust power settings;
- USB Type C allows for smart charging and is energy-efficient;
- Work is ongoing to make USB Type C fully compliant with the Radio Equipment Directive.

The final remarks on potential standardisation solutions were the following:

- It is difficult to estimate any impact if no clear option is defined;
- An intervention would be justifiable only in the presence of a significant market failure;
- In general, voluntary agreements within the industry should be preferred;
- The only satisfactory option would be to standardise the cable at the EPS side;
- There may be an impact on international trade under WTO rules;

- Some unintended negative consequences would be:

  - Increased e-waste;
  - Decreased innovation;
  - Competition distortion;
  - Consumer choice restriction;
  - Increase in size, weight, and cost of chargers;
  - Illicit market expansion.

Annex C: Consumer panel survey synopsis report

The Consumer Survey (CS) was carried out in June 2019 and collected responses from a little over 5,000 respondents across 10 different European countries.

The CS was conducted as part of a wider impact assessment seeking to investigate the interoperability of mobile phone chargers within the European Union and inform the European Commission as to whether any action to promote harmonisation of mobile phone chargers is necessary.

This survey collected information about the type of mobile phones and chargers used by consumers, their degree of interoperability, consumers' experience with charging solutions and the extent to which consumers have encountered problems when using mobile phone chargers.

Methodology

The CS was based on a sample of 10 European countries, each with 500 respondents who were recruited through Ipsos' online consumer panel. The achieved sample included a total of 5,002 survey participants living in the Czech Republic, Germany, Spain, France, Hungary, Italy, the Netherlands, Poland, Romania, and Sweden.[101]

The selection of countries included in the survey represented 58% of the entire EU population[102] and sought to account for a variety of EU-28 consumer markets with different affluence levels[103]. The panels of respondents were broadly representative of the population of the 10 countries in terms of key characteristics of interest (age, gender, region).

The survey comprised of six different sections covering the type of mobile chargers in use, their nature of use (whether they are only used for the mobile phone they were sold with or if they were with other devices), their average lifetime, consumer preferences, consumer detriment caused by problems related to the use of chargers, and the level of consumer confidence/experience.

Overview of the respondents

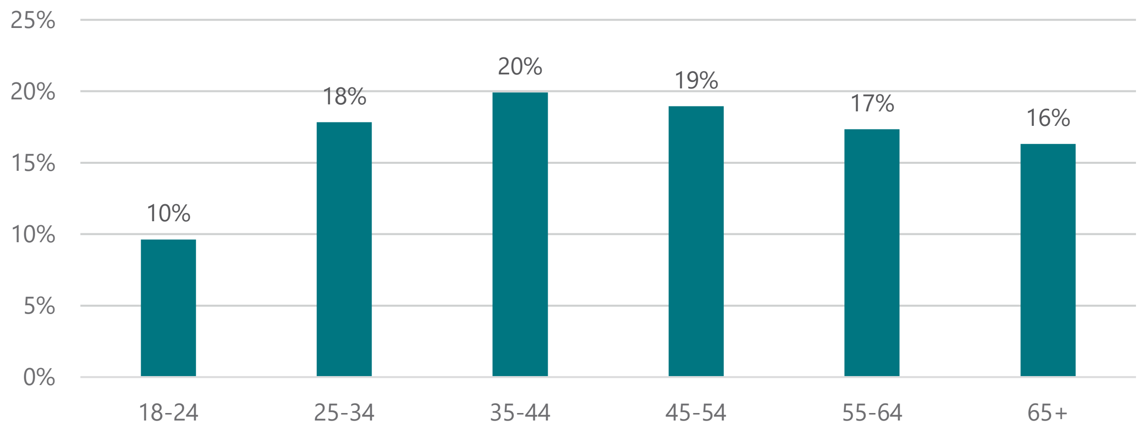
A total of 5,002 respondents distributed equally among 10 countries participated in the survey. The respondent's age groups were heterogeneous. The chart below presents an overview of respondents by age band.

[101] 501 responses were collected in Czech Republic and Hungary.

[102] Calculation based on: Eurostat (2019). *Population change - Demographic balance and crude rates at national level*. [online] Available at https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_gind&lang=en [Accessed 28 August 2019]

[103] Based on: Eurostat (2019). *Real GDP per capita*. [online] Available at https://ec.europa.eu/eurostat/databrowser/view/sdg_08_10/default/table?lang=en [Accessed 28 August 2019]. Variance of real GDP per capita in 2018 for the selected countries: 142104400.

Figure 39: Population sample distribution by age group (unweighted)



Source*: Ipsos consumer survey (2019). N=5,002*

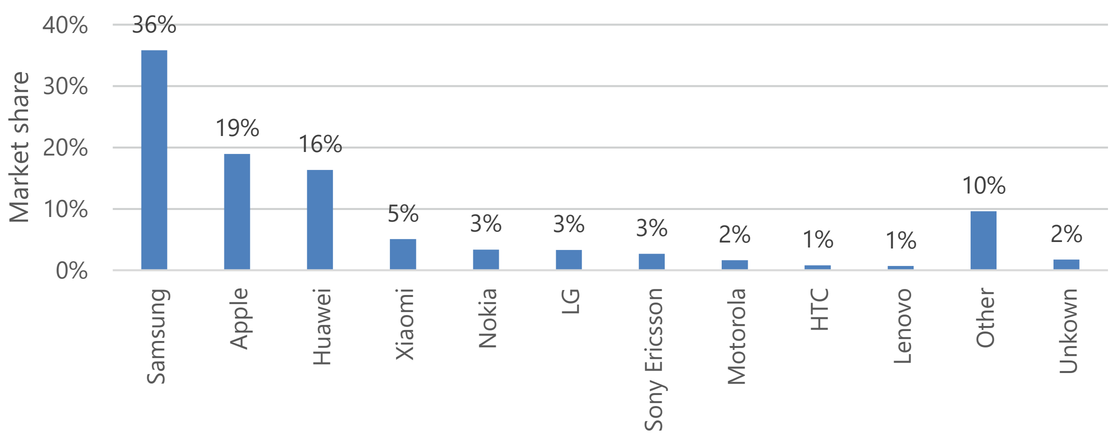
In order to achieve a representative sample across the 10 EU MS covered, responses were weighted by participating countries' age and gender distribution, in addition to total population size of individual countries.

Overview of consumer characteristics relative to mobile phones

Mobile phones used

Consumers participating in the interview were asked to list up to two mobile phones (e.g. a personal device and a work device) that they were using at the time of the survey. The most popular brand among consumers was Samsung (36 %), followed by Apple (19%), and Huawei (16%).

Figure 40: Please provide the brand of the mobile phone you are currently using most often

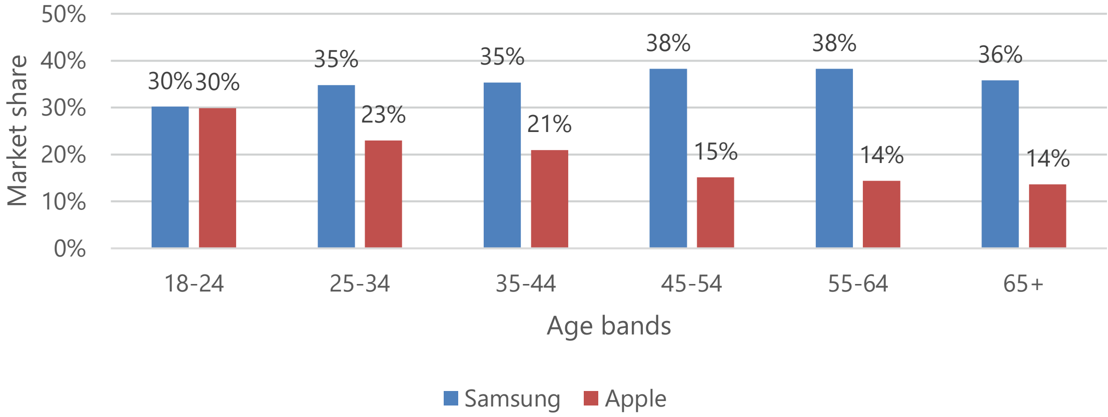


Source*: Ipsos consumer survey (2019). N=5,002*

6% of Samsung users and 2% of Huawei users declared that they owned an Apple phone as well, while 1 in 10 Apple users also owned a mobile phone of another brand.

Apple phones are most popular amongst the youngest respondents included in the sample when compared to other age bands, on par with Samsung phones. For all other age brackets, Samsung devices are more popular.

Figure 41: Please provide the brand of the mobile phone you are currently using most often



***Source**: Ipsos consumer survey (2019). N=5,002*

Number of phone chargers used

Survey participants stated using an average of two mobile phone chargers. There were no notable differences by age group.

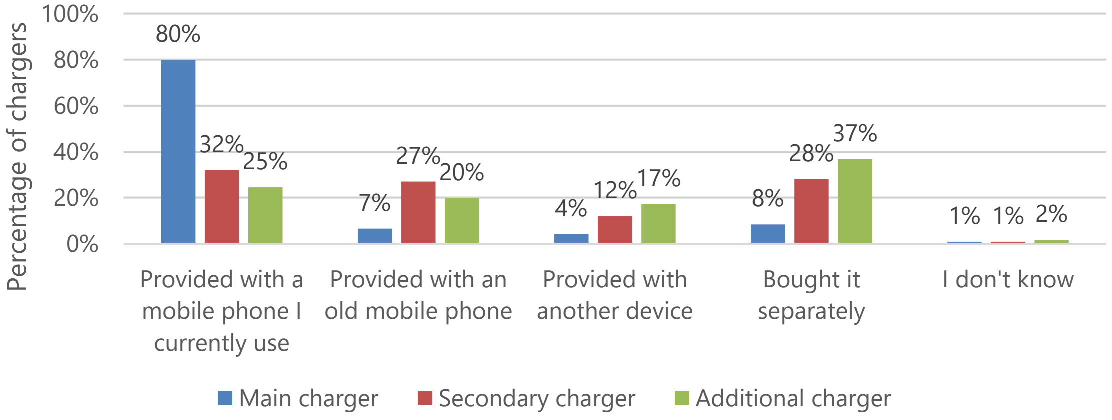
Number of phone chargers owned

The survey continued by asking respondents about the number of mobile phone chargers owned – i.e. irrespective of whether they were used or not. On average, respondents reported that they own three chargers.

Chargers supplied with mobile phones

80% of respondents indicated that the main charger they were using had been provided with their current mobile phone, whilst 32% reported that they were using the charger provided with their current mobile phone as a secondary charger and 25% as an additional charger. Chargers provided with an older mobile phone were used as main charger by 7% of respondents, whilst 27% indicated that they were using them as secondary chargers, and 20% as a third, additional charger. Chargers of other electronic devices were used as main mobile phone chargers by only 4% of respondents, whilst 12% used them as secondary chargers, and 17% as additional chargers. Only 8% of respondents had bought separately their main charger; 28% had bought their secondary charger separately, and 37% had bought separately an additional charger.

Figure 42: For each charger, can you please tell me whether they were supplied together with a mobile phone?



Source: *Ipsos consumer survey (2019). N=5,002*

Reason for not purchasing a mobile phone charger in the 5 years prior to the consumer survey

45% of all respondents never purchased a charger in the 5 years prior to the survey. 93% of respondents indicated that they were supplied with a new charger when purchasing a new phone and for this reason they did not purchase another mobile phone charger in the 5 years prior to the survey. 13% indicated that they were able to re-use a charger from a previous phone, while 7% used a charger from a device of another type.

Types of connectors on the device (phone) end

Further questions were aimed at presenting an overview of the type of chargers that respondents normally used with their phones. 100% of respondents with an iPhone indicated that their chargers were based on Lighting technology (only 3.4% among non-iPhone users).

USB micro B is the most common connector type (95%) among respondents that do not own an iPhone, followed by USB Type C connectivity (51%). Moreover, 54% of respondents aged 18 to 24 reported using USB Type C connectivity compared to only 27% of those aged 65 and over. This could be due to a higher propensity of younger people to purchase newer or more high-end mobile phones which are more likely to incorporate this technology.

Types of connectors on the EPS end

Respondents were then asked about the EPS' connectivity characteristics. In this case, USB A is the most common connector (82%), with 7% and 3% of respondents reporting Type C or both USB A and USB Type C connectivity, respectively.[104]

Charging time

In terms of charging times, 51% of the sample indicated a charging time of less than 90 minutes, whilst 59% reported charging times were between 90 minutes and 2 hours. 30% of respondents cited that their phone took between 2 and 3 hours to

[104] However, it must be noted that 7% of respondents reported having a different, unspecified type of connection.

complete a charge cycle, whereas only 13% claimed that their phone took more than 3 hours to charge. The fact that the respondents may have more than one charger or one phone results in having some respondents that indicate different charging times.

Fast-charging EPS

When asked whether their EPS had fast charging capabilities, 72% of respondents stated this was not a current feature, and 54% stated that it was. 38% were unclear whether it was. When multiple chargers were owned, secondary and tertiary chargers were less likely to be fast-charging enabled (decreasing from 36% for the primary charger, to 28% for the tertiary charger).[105]

Use of chargers

Interoperability of chargers

Respondents were then presented questions related to the extent to which they take advantage of the interoperability of the chargers that they use. Most respondents (63%) indicated that they only charged their primary mobile phone with their primary charger. However, people aged 65 and over were more likely to use only their primary charger with their mobile phone (71%) compared to those aged 18 to 25-years old (59%).

15% of respondents indicated that they used their mobile phone chargers to charge other mobile phones; younger people (18-24) were more likely to do so (19%) relative to people aged 65 and over (11%). A minority of respondents (14%) used their mobile phone chargers with other electronic devices; in this case, no clear pattern emerges when considering age bands. Among those who utilised their phone charger for other devices, 65% used it to charge tablets. Interoperability with other devices appears limited; only 19% charged wireless speakers with their mobile phone charger and 18% e-readers. iPhone users seem to be more likely to use their phone charger with tablets (75%) compared to non-iPhone users (62%). Yet, non-iPhone users tend to use their mobile phone charger more for e-readers (21% vs 9%). Only 3% of respondents indicated that they were able to charge their laptops with their phone chargers.

Cable and EPS interoperability

Most respondents who used their phone chargers for other mobile phones and/or other devices used both the cable and the EPS (58% for mobile phones and 53% for other devices). Differences are clear between iPhone and non-iPhone users; while approximately 48% of iPhone users indicated that they used both the cable and EPS for other mobile phones, 60% of non-iPhone users did this. 16% did not use their mobile phone charger (cable and EPS) to charge other chargers, but only for other electronic devices (15% among non-iPhone users, 22% among iPhone users).

When considering interoperability with other electronic devices, results are more mixed. iPhone users were more likely to use only the EPS to charge other devices compared to non-iPhone users (28% and 15% respectively).

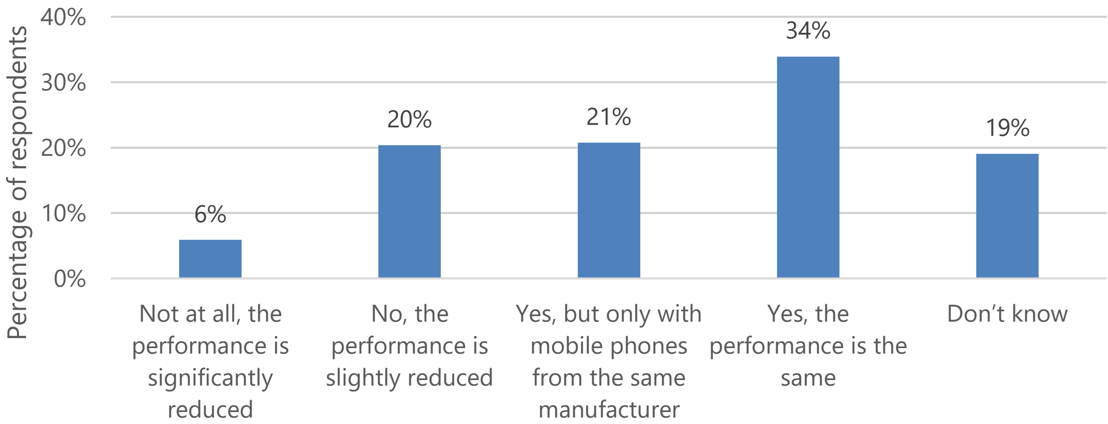
Charging speed with other mobile phones

Among those respondents who used their phone charger to charge other phones, 26% reported had recollection of performance issues when using their primary charger to

[105] It must be noted that 23% of respondents were unable to indicate whether their charger was fast-charging enabled; uncertainty is homogeneous across all age groups.

charge other mobile phones. However, iPhone users were more likely (32%) to indicate that the charging speed was not affected if they used another Apple charger to charge their phones, compared to non-iPhone users who indicated that the charging speed was not affected when using another charger from the same brand as their mobile phone (19%).

Figure 43: Does your charger provide charging at the same charging speed when charging other phones?



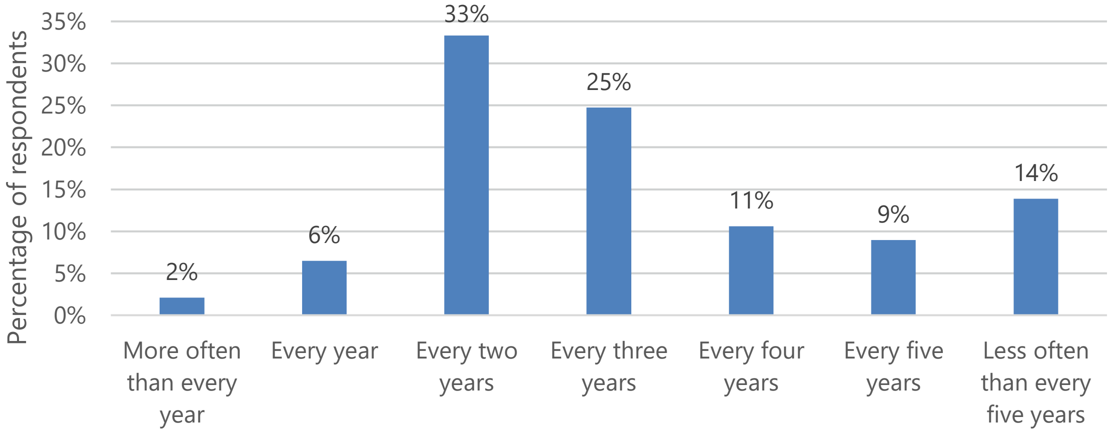
***Source**: Ipsos consumer survey (2019). N=1,206*

Consumer habits

Purchase frequency of new mobile phones

In the 5 years prior to the survey, one third of participants purchased a new phone every 2 years, while 25% bought a new mobile every 3 years. Participants aged 18 to 25 are more likely to replace their mobile phone every year than those aged 65 and older (14 and 4% respectively).

Figure 44: In the past 5 years, how often have you acquired a new mobile phone for personal use?

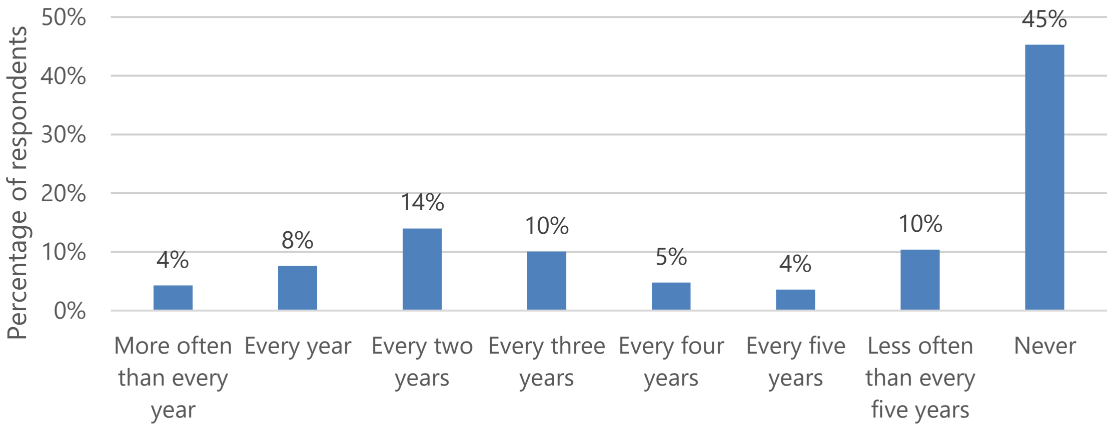


***Source**: Ipsos consumer survey (2019). N=5,002*

Purchase frequency of new phone chargers

Purchasing new chargers separately from a mobile phone seems more infrequent than purchasing new mobile phones. 48% of non-iPhone users and 33% of iPhone owners did not purchase any charger in the 5 years prior to the survey. However, there seems to be a difference by age; 15% those aged 18 to 24 bought a charger every year, compared to only 3% of those aged 65 and above.

Figure 45: In the past 5 years, how often have you purchased a new mobile phone charger separately?



***Source**: Ipsos consumer survey (2019). N=5,002*

Reasons for purchasing a new charger

A broken mobile phone charger cable was the main reason for buying a charger (36% of cases). The second most cited cause was the convenience of having a spare charger (28%). Travelling and needing an extra charger was the third most important reason (15%), followed by losing the original charger (14%), damage to the EPS (10%), wanting a faster charger (8%) or a wanting wireless charger (3%). 6% mentioned other reasons. Only 3% reported the reason for buying a charger was that their phone did not come with a charger.

Characteristics of the new charger purchased

31% bought an unbranded charger, whereas 25% purchased one from an unknown brand. A charger of a known brand, but not matching that of their mobile phone, was the choice of 21% of respondents. 13% of respondents were unable to provide information on the brand of their chargers. 11% bought a charger that was the same brand as the mobile phone they were mainly using at the time.

When buying a new charger, 47% did not buy a fast charging-enabled charger or a wireless charger. 39% opted for a fast-charging model, 8% were wireless and only 6% were both fast-charging and wireless.

The two most important factors underpinning the choice of charger where compatibility with the mobile phone in use (56% of cases among those who had purchased a new mobile phone charger in the previous 5 years) and price (41%). The time a charger would take to fully charge the phone was indicated as important by 18% of those who had purchased a new mobile phone charger. 18% also paid attention to whether the charger had safety certifications. Interoperability of the charger with other electronic devices was considered important by 12%. Other elements were considered of less importance: lifetime of charger (11%), a charger matching the phone brand (10%), wattage (6%), multi-port functions (5%), and weight (2%), or any other elements (3%).

Disposal of used chargers

Accumulating chargers at home was the single most common way of dealing with old chargers (49% of cases). 23% of respondents declared that they disposed of old chargers by using recycling facilities, whilst 7% considered them generic waste. 17% re-used old chargers, and 14% passed them on to family or friends. Selling used chargers online was common only among 5% of respondents.

Charger accessories

51% of respondents make use of charger accessories, whilst 46% do not, and 3% do not know. However, most of those who have a charging accessory have a power bank (34%) or multi-port charger (12%). 11% have fast-charging accessories, and 8% wireless charging accessories.

Among those that possess a fast-charging device, 36% own one because they were in a bundle with the phone, whereas 25% bought one exclusively for faster charging. Wireless charging was included in the phone package in 12% of cases, while 32% bought a wireless charger for convenience. Convenience was also indicated as the reason behind the purchase of power banks (38%).

Consumer preferences

Willingness to buy a phone without a charger

Respondents were also asked whether they would consider buying a phone without a charger (meaning without EPS and cable). 40% of respondents were not willing to buy a new mobile phone without a charger in the box. 45% of respondents were willing to buy only a phone without charger, but as a result of this, 36% indicated that they would expect a discount on the price of the mobile phone. 11% indicated to expect a reduction of either 20 or 50 Euros; 8% considered that 30 Euros was an adequate discount, 7% would have been satisfied with a 10-Euro discount. Only 9% of participants would buy a phone without a charger without monetary compensation. However, the share of undecided respondents is high (14%). Although there are no clear differences between iPhone and non-iPhone owners, younger individuals are generally more willing to accept a discount rather than buying a new phone together with a new charger.

Among those who were unwilling to consider buying a phone without a charger, 68% indicated that the charger provided with the new phone saved the trouble of finding the right charger. The bundle was also perceived as an assurance that the charger would work properly (38%), that it was safe because from the same brand as the phone (35%), and that it would charge the mobile phone efficiently (23%).

55% of those that would consider buying a phone without a charger would do so for environmental reasons, as they indicated that it would help them to save resources and reduce e-waste. Having too many chargers was indicated as a reason for not buying a phone and a charger together by 46% of respondents, while 40% would prefer buying only the phone with an expected price reduction.

Willingness to buy a phone without an EPS

Respondents were also asked whether they would consider buying a phone with only a charging cable provided, but without an EPS. 36% indicated that they would not support this option, 18% had no opinion, and 46% would be willing to buy a phone with only a cable included in the box. 12% would be willing to accept this without any price reduction. 8% would expect a price reduction of 5 Euros in order to buy a phone without an EPS but only with a charging cable included in the box; 11% expected a 10-Euro reduction, and 15% a 15-Euro discount.

Among those that would not like to buy a phone with only a charging cable, but without EPS, 61% explained that they would not want to worry about how they could charge the phone. 37% indicated that having cable and EPS ensures that the power supply works well, and 26% that performance standards are unaffected. 10% would prefer buying a phone with neither the cable nor the EPS, and 5% had other reasons.

When considering those that would be willing to purchase a mobile phone with only a charging cable included, 52.9% would do so to save resources and reduce e-waste, 46% for reasons of convenience, as they already had too many EPSs, and 37% to save money.

Conjoint experiment

Respondents where then asked to indicate their preferred mobile phone chargers based on a choice of chargers with a combination of different attributes. This conjoint module allowed to identify the elements of a mobile phone charger that consumers perceived as more important relative to other features, which then would be used to model the monetary premium that consumers were willing to pay for the improvement of certain of these mobile phone chargers attributes.

Thus, the conjoint experiment provides a measure of the relative utilities (or importance) of a set list of relevant mobile phone characteristics based on the preferences expressed by a group of 4,906 respondents.

It appears that price was the single most important factor when choosing a mobile phone charger (32% of relative importance), followed by the type of connector on the EPS and on the device side (26% relative importance). Charging time was the third-most important feature that consumers considered when choosing a charger (16% relative importance). Brand had 11% of relative importance, followed by interoperability with other electronic devices other than mobile phones (10% of relative importance). The least important factor among those that consumers were presented with was interoperability across different types of mobile phones (6% of relative importance).

Problems with chargers

Frequency of problems

A further set of questions investigated the nature and frequency of problems encountered by consumers in the use of mobile phone chargers. Overall, 84% of respondents had experienced at least one of the following problems at least once or twice in the 24-month period prior to the survey. As regards the different types of problems (see Figure 46 overleaf):

- The inconvenience of not being able to use a previous charger to charge a new phone was experienced once or twice by 14% of respondents. 14% reported that the problem occurred a few times, on numerous occasions at 10% and almost daily at 9%). 53% of participants experienced no problems of this nature.

- Difficulties in charging other devices with the primary phone charger occurred once or twice for 14% of respondents, a few times for 20%, 10% of respondents on numerous occasions and 5% nearly daily. Half of those participating reported no experience of problems occurring.

- Chargers taking up space at home or at work was indicated as an issue occurring once or twice for 17% of consumers, on a few occasions for 20%, on numerous occasions for 12%, and for 5% almost on a daily basis.

- Preference for using an older charger despite being provided a new one with every new phone was indicated as a problem which had occurred once or twice by 15% of respondents, a few times by 13%, on numerous occasions by 7%, and almost every day by 4%. 60% never experienced this problem.

- In terms of charging speed, problems arose once or twice for 18% of respondents. 24% of consumers experienced this problem on a few occasions when they tried to charge their phones with other chargers. 9% reported problems on several occasions and 2% almost daily. However, 47% indicated that they had never experienced problems in the reference period.

- Confusion over which charger to use for other electronic devices was indicated as a problem occurring almost every day by 1% of respondents, by 5% on numerous occasions, by 14% a few times, by 15% once or twice, and never by 65%.

- Safety issues were also indicated as a problem by 30% of respondents, although they tended to occur with low frequency: 15% once or twice, 11% a few times, 4% on numerous occasions, and 1% almost daily.

- Confusion over which charger to use for different mobile phones was a problem for 30% of respondents. For 1% it happened almost every day, for 5% on numerous occasions, for 12% a few times, and for 13% once or twice.

- When needing to charge their phone, 19% of respondents reported having experienced problems once or twice because all other chargers were incompatible, 15% had this problem on a few occasions, 3% on numerous occasions and less than 1% almost daily. 63% did not face problems relative to interoperability of other chargers.

- Other problems affected 23% of respondents.

Severity of problems

The severity of these problems was further investigated among all respondents (see Figure 47 overleaf):

- Considerable inconveniences relative to charging speeds when using other chargers regularly affected 4% of all respondents, whilst significant issues were experienced from time to time by 17% of respondents. 31% of respondents, although being affected by this problem, did not consider it serious.

- Having too many chargers taking up space at home or in the workplace caused significant issues on a regular basis to 6% of all respondents. 15% considered it a problem causing significant issues only from time to time. 31% of respondents, despite that they had experienced this issue, did not consider it as a serious problem.

- Being unable to charge other electronic devices with the main phone charger seemed to be a significant problem occurring on a regular basis for 6% of all respondents. 15% found this to cause significant issues from time to time, whilst 28% did not consider it a serious problem.

- 6% of all respondents indicated that being unable to charge their new phone with an old charger was perceived a serious problem on a regular basis. The problem was still significant, but only occurred from time to time, for 15% of respondents. 25% of respondents still experienced this problem but did not consider it serious.

- Being provided with a new charger with every phone purchased although one would have preferred to use an old charger was indicated as a problem causing significant issues on a regular basis by 4% of all respondents. 11% considered it a significant problem from time to time, whilst 25% deemed it to be a problem that did not cause any significant issues.

- Not being able to charge a mobile phone because all the available chargers were incompatible was reported as a significant issue occurring on a regular basis by 4% of all respondents, whilst 15% of respondents indicated that incompatibility of phone chargers was a significant issue from time to time. Although 19% of respondents experienced this issue, they did not consider it a serious problem.

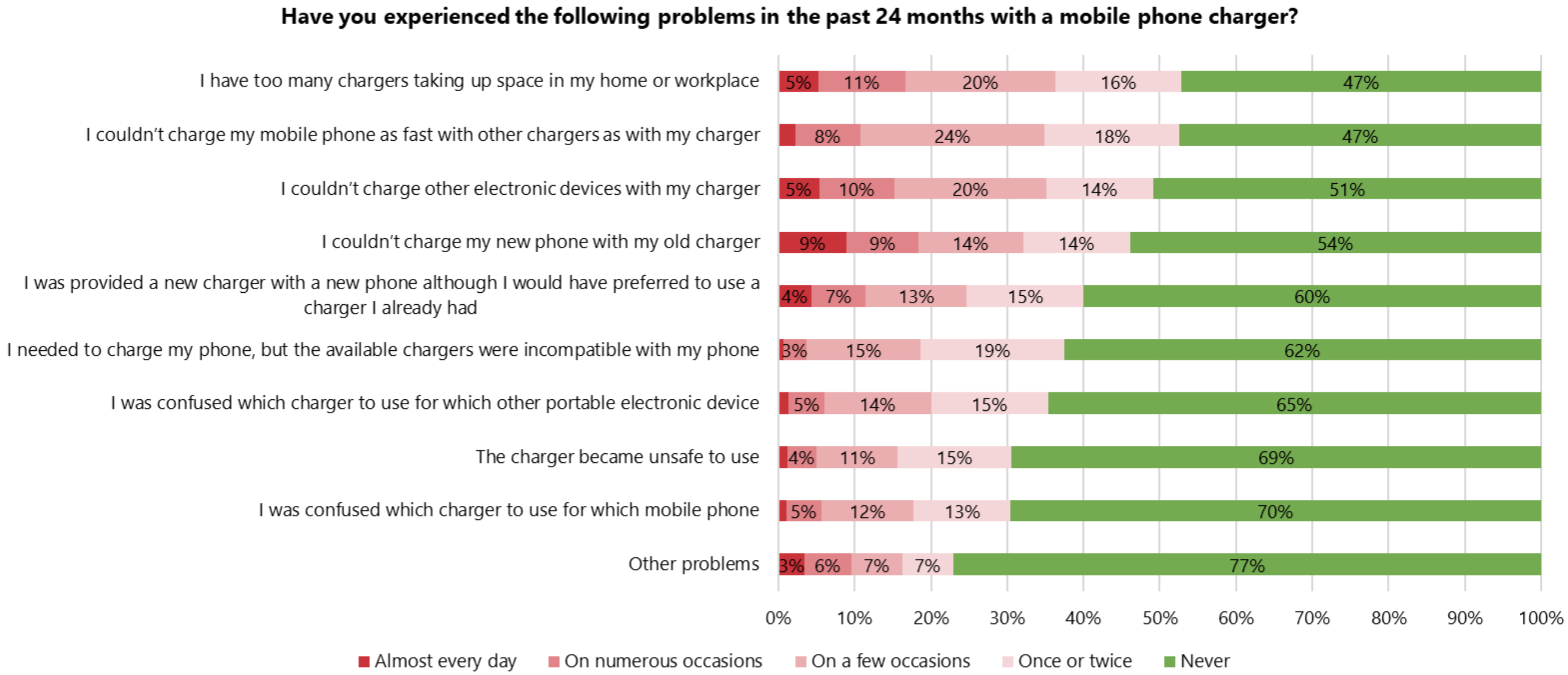
- Being confused about which charger to use for other portable electronic devices was considered a significant problem happening regularly by 4% of all respondents. 14% reported that it caused them significant issues from time to time. 18% experienced this problem but did not find it serious.

- 3% of all respondents who indicated that they were confused about which charger to use for which mobile phone considered this as a significant issue on a regular basis. 12% of respondents were significantly affected by this problem from time to time, whilst 15%, despite having experienced it, did not considered this as a serious problem.

- 5% of all respondents found that having a charger that became unsafe to use was regularly a significant problem. 14% considered this a problem causing significant issues from time to time, whilst for 11% of respondents it has been a problem without significant consequences.

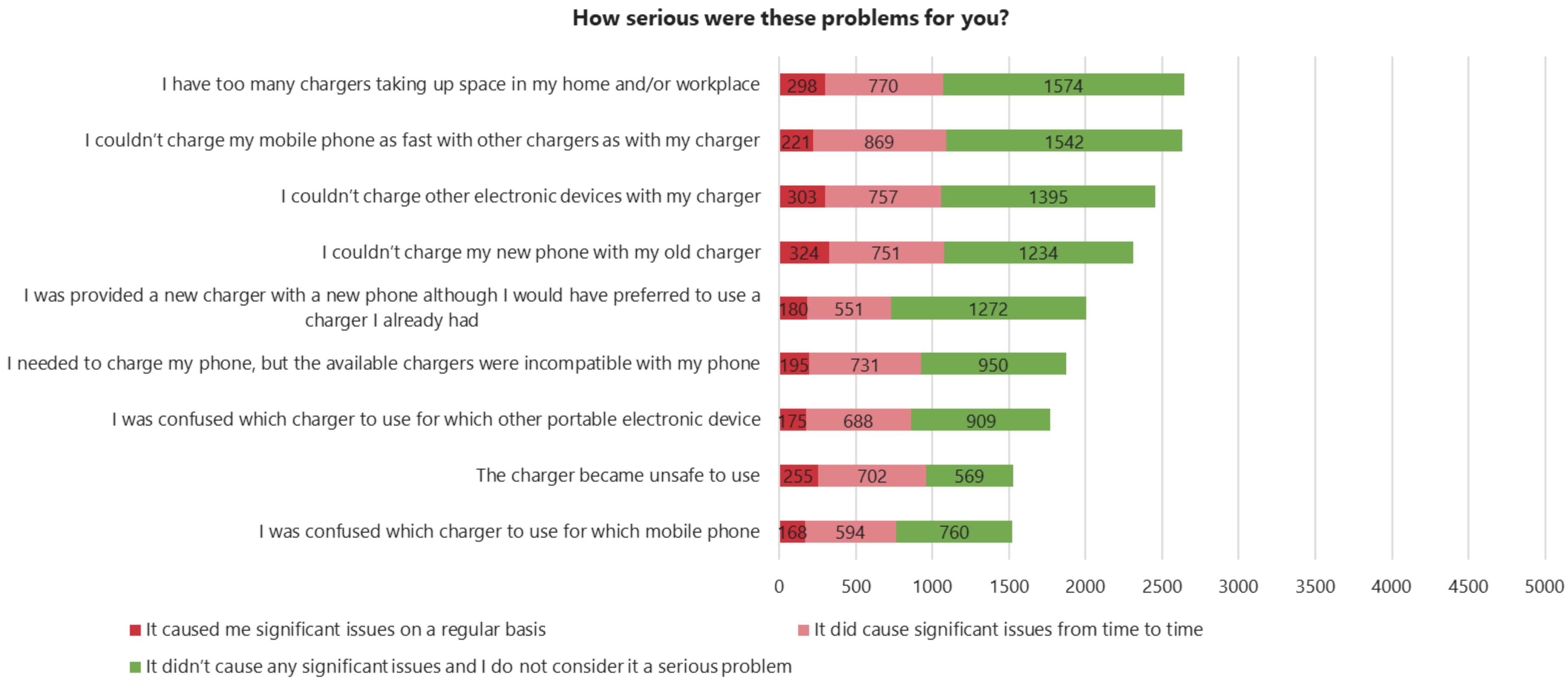
- Other problems were perceived as significant by 1% of all respondent, who had experienced them from time to time. Another 1% had had significant problems of other nature but they were not considered serious.

Figure 46: Share of all respondents experiencing problems with a mobile phone charger



Source: Ipsos consumer survey (2019), N = 5,002

Figure 47: Number of respondents by seriousness of problem reported



Source: Ipsos consumer survey (2019), N = 1,564 – 2,624

Responses to problems

When problems arose, nearly one third of respondents (36%) tended to take no action. 27% of participants resorted to using another charger that they already had, while 17% purchased a new one. 7% formally requested a replacement, 7% returned the charger to the place where they had bought it, 7% bought an adapter, 5% asked for a refund, 4% asked for a price discount, and 3% made a complaint to the place where they bought the charger. 1% took other measures, whilst 2% did not recollect what their actions were.

For those that indicated no action was taken, the single main explanation for this was that the problem was not perceived as serious enough (50%). The perception that any action would take an excessive amount of time and effort was a deterrent for 20% of respondents. Other reasons presented as response options, such as not knowing how to complain or not wanting to wait, were all reported at 6% or below.

Costs

Within the same 24-month reference period, only 15% of respondents who experienced problems reported incurring any financial costs as a result of a problem with their chargers. The share of respondents that had to bear costs as a result of problems with their chargers was higher among those aged 18 to 24 (27%) than among the older groups of the population (for those aged 65+, only 6% reported financial costs).

When asked to quantify these costs, average expenditure for stationery, postage, or calls was indicated at 52 Euros, with a peak of 73 Euros among those aged 35 to 44 and 67 Euros for those aged 25 to 34.

Repairing or resolving the problems at own expenses was reported having an average cost of 31 Euros, with a peak of 47 Euros among the 35-44 cohort, followed by 34 Euros paid by those aged 18 to 24.

The average loss of financial earnings from work stood on average at 57 Euros. The impact was greatest among the younger group (18-24 year-olds), followed by the group aged 55 to 64. Those aged 25 to 34 indicated the loss at 59 Euros, and those aged 45 to 54 estimated the loss to be 18 Euros. The oldest cohort (65+) considered that the problems had caused a loss estimated in 8 Euros.

1 in 4 respondents experiencing problems spent time trying to fix the problems experienced with their chargers for an average of 6 hours

Persistence of problems

At the end of the CS, respondents were asked whether the problems they had experienced had been resolved fully or in part. For all the issues previously discussed, most respondents indicated that the problems were at least partially resolved.

Being unable to charge a phone because all the available chargers are incompatible was considered a completely resolved issue by 48% of respondents who had experienced this problem, partly resolved by 32%, and not resolved by 12%. The remaining share of respondents either refused to answer or did not know how to answer.

Among those who had experienced lower speed when charging a phone with other chargers, 43% considered the problem completely resolved, 30% as partly resolved, and 14% as unresolved.

Being unable to charge other electronic devices with a mobile phone charger was considered a resolved problem by 40% of those who had experienced it, a partly-resolved problem by 24%, and an unresolved problem by 21%.

Being unable to charge a new phone with an older charger was indicated as completely resolved by 48% of respondents who had indicated having this problem, as partly resolved by 20%, as unresolved by 20%.

Being provided with a new charger when purchasing a new phone although one would have preferred using a previous charger was considered as a resolved issue by 46% of those who had had this problem, partly resolved by 20%, and unresolved by 19%.

Among those who complained about having too many chargers taking up space at home or at work, 28% judged the problem as resolved, 29% as partly resolved, and 30% as unresolved.

Being confused over which mobile phone charger to use for which mobile phone was a resolved problem for 42%, a partly resolved problem for 32%, and an unresolved issue for 14%.

The problem of being confused over which chargers to use for other portable electronic devices was considered resolved by 42% of those who had had this problem, whilst 33% considered it partly resolved, and 13% not resolved at all.

The fact that the charger had become unsafe to use was not a problem anymore for 49% of those who had experienced it, for 25% was a partly resolved issue, and for 12% was not resolved.

Annex D: Market data and information on other portable electronic devices

The following pages contain relevant information and data on a number of types of portable electronic devices, based on a review of publicly available market data and a desk-based review of key characteristics of a sample of products in each category.

Smartphones

Product characteristics

Description of the product

Smartphones are mobile phones with computer features, generally based on an operating system. In addition to a set of core functionalities that are typical of mobile phones, such as making and receiving phone calls or sending text messages through cellular networks, smartphones also allow the user to utilise internet-based services and multimedia functions.

Charging characteristics of the product

Based on a review of a sample of 10 popular smartphone models from various brands, we have observed that smartphones require a minimum of 1A and 5V (total of 5W) and a maximum of 2.5A and 12V (total of 18W).

All the 10 smartphones in the sample were sold with both the EPS and the charging cable in the box. Most of the mobile phones in the sample (7 out of 10) were based on USB Type C connectors, two had USB micro B connectors, and 1 had a Lighting connector. However, our analysis of market data from IDC (see section 3.3 of this report) shows that this is not representative of the market: in 2018, approx. 50% of all mobile phone sold in the EU had USB micro B connectors, while 29% had USB Type C connectors, and 21% had Lightning connectors.

Table 38: Smartphone charging characteristics

	Current		Voltage		Power	
	Max	Min	Max	Min	Max	Min
Smartphones	2.5A	1A	12V	5V	18W	5W

Source: *Ipsos's own research (2019) based on a sample of 10 smartphones.*

Market characteristics

Data sources

Data is based on an estimation of total mobile phone sales in the European Union drawing on the results of the Stock Model presented as part of this study.

Location of manufacturers

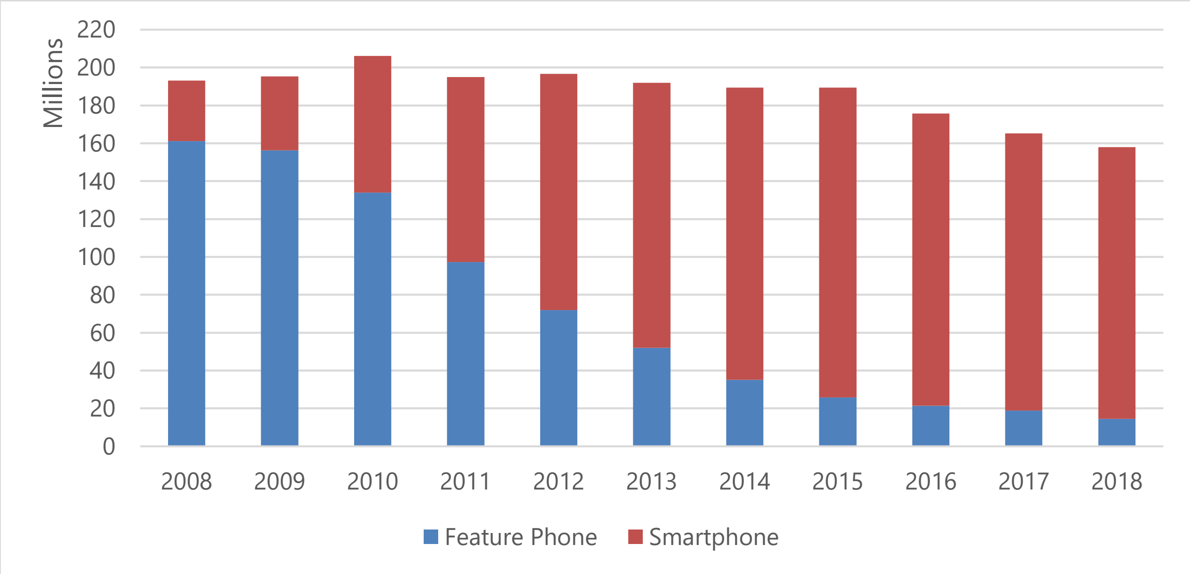
There is a small number of manufacturers of mobile phones based in Europe: BQ is based in Spain, Brondi in Italy, Fairphone in the Netherlands, Gigaset in Germany, Lumigon in Denmark, and Nokia in Finland. However, their market share is very small.

The main manufacturers are headquartered mainly in Asia (China, Japan, South Korea, and Taiwan) and in the United States.

Data on market trends

As illustrated in Figure 48, smartphone sales across the EU increased spectacularly between 2008 and 2015, both in absolute terms and as a proportion of all mobile phone sales. Since then, sales have fallen slightly, from a peak of 164 million in 2015, to 144 million in 2018. Smartphones now account for over 90% of all mobile phones sold in the EU, with feature phones responsible for the (shrinking) rest.

Figure 48: Mobile phone sales in the European Union



***Source**: IDC Quarterly Mobile Phone Tracker, Q1 2019*
NB: IDC data covers 24 EU Member States, which represent 99% of the EU's population.

Tablets

Product characteristics

Description of the product

Tablets are electronic devices that are normally larger in size than a smartphone, but smaller than a laptop. Tablets often run an operating system that allows them to perform computer-like functions and have different types of connectivity: Bluetooth, Wi-Fi, or 4G, or any of the previous types combined, depending on the product.

Charging characteristics of the product

The 11 tablets in the market sample examined for this study require a minimum current of 1 A and 3.76V of voltage (total of 9.36W) and a maximum of 3.25A and 20V (total of 65W).

All the devices in the sample had both the EPS and the cable in the box. There is no clear prevalence of one type of connectors over the others on the device side: 4 have proprietary connectors (including 2 Lighting) and 3 have USB micro B, whilst 3 tablets have instead USB Type C. No information is available on the connector of the remaining tablet.

Table 39: Comparison of charging characteristics between tablets and smartphones

	Current		Voltage		Power	
	Max	Min	Max	Min	Max	Min
Tablets	3.25A	1A	20V	3.76V	65W	9.36W
Smartphones	2.5A	1A	12V	5V	18W	5W

Source: *Ipsos's own research (2019) based on a sample of 11 tablets.*

Market characteristics

Data sources

Strategy Analytics provides market research information on ITC-related firms and markets. Data on tablet shipments is sourced from a series of press releases and covers the first quarter of each year between 2015 and 2019. However, data is only available for shipments in the world, with no geographical breakdown. eMarketer data provides additional information on shipments to Western Europe, with forecast data for the years 2017 and 2018.

Data on tablets was not available from Comtrade or other public databases on international trade due to the inexistence of a TARIC specific code for this type of devices. The study team was not able to find public data on shipments of tablets to the EU.

Location of manufacturers

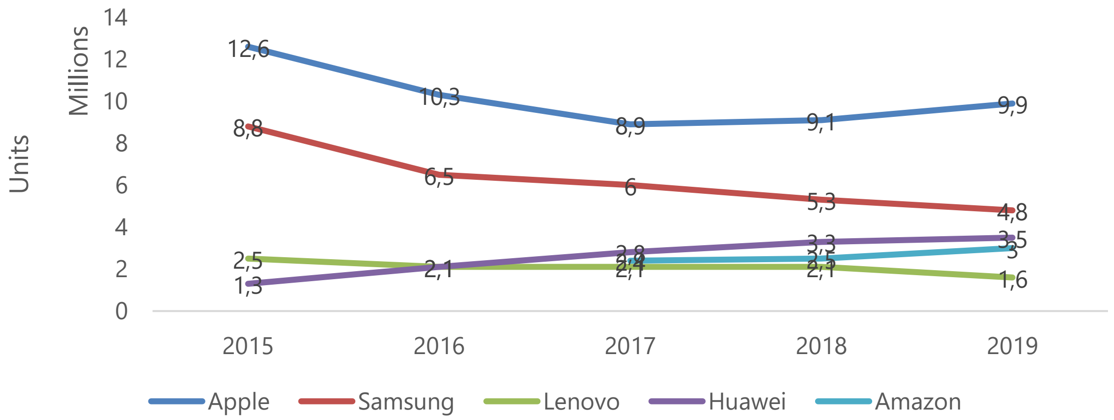
Tablets manufacturers are mainly based in Asia or in the United States.

<u>Data on market trends</u>

According to data from the Consumer Survey conducted by Ipsos, tablets may be the most popular portable device after smartphones, as 65% of the respondents that use their mobile phone chargers to charge also other devices use them to charge tablets.

Strategy Analytics' data provides an overview of tablet shipments by manufacturer at the global level between 2015 and 2019, as shown in Figure 49.

Figure 49: Tablet worldwide shipments



Source: *Strategy Analytics (2019)*[106].
Note: *Data is only presented for the first quarter of each year for reasons of consistency and is provisional for years 2017, 2018, and 2019.*

Figures are available for five main manufacturers: Amazon, Apple, Huawei, Lenovo, and Samsung. Apple seems to be the largest manufacturer of tablets among the five brands, with shipments being consistently higher than any other competitor in the sample between 2015 and 2019. In the first quarter of 2015 worldwide shipments of tablets peaked at 41.8 million and declined gradually until the first quarter of 2019, when sales were expected to increase, reaching 22.8 million units. Apple was the market leader throughout the period included in the analysis, followed by Samsung, which was reported consistently as the second-largest manufacturer in terms of shipments.

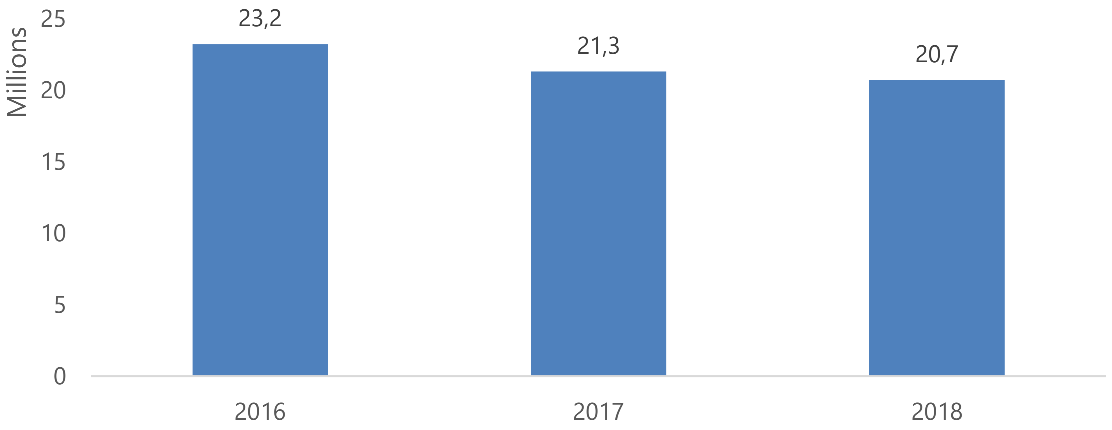
Figures specifically for Western Europe show that shipments decreased between 2016 and 2018. In 2016, 23.2 million tablets were shipped in Western Europe, compared to a forecast of only 20.7 million devices in 2018, as illustrated in Figure 50.

[106] Strategy Analytics (2019). *Handful of Tablet Vendors Consolidate Leadership Positions in Q1 2019 as Market Falls 5%*. Accessed at: https://news.strategyanalytics.com/press-release/devices/strategy-analytics%C2%A0handful-tablet-vendors-consolidate-leadership-positions on 17 September 2019.

Strategy Analytics (2017). *Windows Tablets Falter as Tablet Market Falls 10% in Q1 2017.* Accessed at: https://www.strategyanalytics.com/strategy-analytics/news/strategy-analytics-press-releases/2017/05/04/windows-tablets-falter-as-tablet-market-falls-10-in-q1-2017 on 17 September 2019.

Strategy Analytics (2016). *Q1 2016 Was the Worst Quarter for Tablets Since 2012*. Accessed at: https://www.strategyanalytics.com/strategy-analytics/blogs/devices/connected-computing-devices/tablets/2016/04/28/q1-2016-was-the-worst-quarter-for-tablets-since-2012 on 17 September 2019.

Figure 50: Tablet shipments in Western Europe



Source: *eMarketer (2017)[107].*
Note: *Data for 2017 and 2018 is forecast.*

[107] eMarketer (2017). *Among Tablet and PC Shipments in Western Europe, Slate Tablets Retain Top Spot*. Accessed at: https://www.emarketer.com/Article/Among-Tablet-PC-Shipments-Western-Europe-Slate-Tablets-Retain-Top-Spot/1015446 on 11 November 2019.

E-readers

Product characteristics

Description of the product

E-readers, also known as e-book readers, are devices designed for the purpose of reading e-books, newspapers, and other documents. E-readers screen are often based on electronic ink technology, generally requiring less power to function compared to other touch screen technology, but they are also less sensitive to tactile inputs compared to other devices such as tablets and smartphones.

Charging characteristics of the product

In the sample of 8 e-readers included in the analysis, the lowest charging current is 0.5 A and the lowest voltage 3.7V (for a total power of 10W), whilst the highest current is 2.5A and the highest voltage is 5.35V (for a total of 12.5W).

7 out of the 8 e-readers in the sample were sold with only the charging cable in the box, without the EPS, and the majority (7 out of 8) have a micro USB connector, whilst only 1 has a USB Type C connector.

Table 40: Comparison of charging characteristics between e-readers and smartphones

	Current		Voltage		Power	
	Max	Min	Max	Min	Max	Min
E-readers	2.5A	0.5A	5.35V	3.7V	12.5W	10W
Smartphones	2.5A	1A	12V	5V	18W	5W

Source: *Ipsos's own research (2019) based on a sample of 8 e-readers.*

Market characteristics

Data sources

Data from Statista, cited in Vrethager (2017), shows worldwide sales of e-readers between 2010 and 2015.

Data on e-reader imports for the European Union was available from Comtrade, although it was limited to value of imports. However, the product code used might also include other devices alongside e-readers, although it seems reasonable to assume that e-readers constitute the majority of the products in this category.

Location of manufacturers

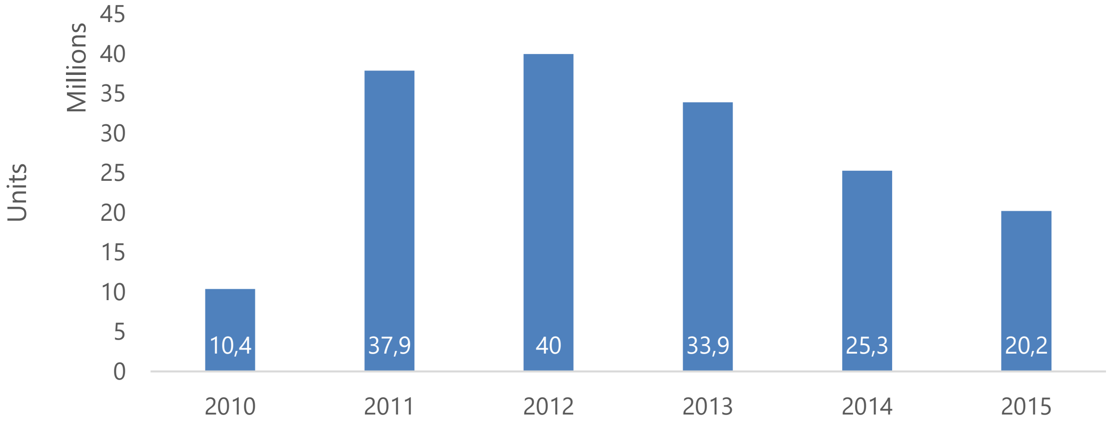
Manufacturers of e-readers are mainly headquartered in Asia, Canada, and the United States. Booken, an e-book reader manufacturer, is based in France. Another manufacturer, reMarkable, is based in Norway.

Data on market trends

As shown in Figure 51, data on units sold across the world between 2010 and 2015 suggests that the market grew rapidly between 2010 and 2011 (surging from 10.4 million units in 2010 to 37.9 million units in 2011). The peak was reached in 2012 with

40 million units sold; after 2012, the trend was downwards up to 2015, the latest available year, where sales stood at 20.2 million.

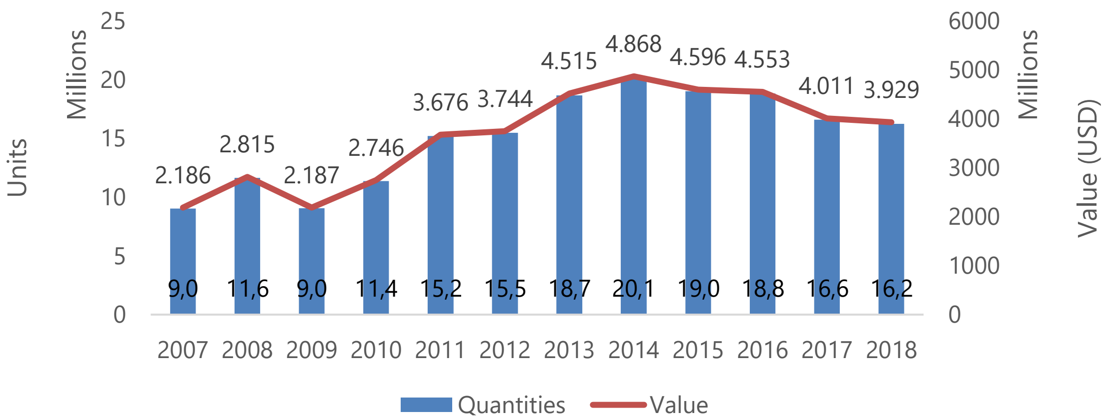
Figure 51: E-readers worldwide sales



Source: *Vrethager (2017). The future of the book industry*[108]*.*
Note: *Figures are based on Statista data.*

Data from Comtrade in Figure 52 shows a clear upward trend in the market for e-readers between 2009 and 2014, when the total value of imports into the EU was over 4.8 billion dollars, followed by a gradual decrease in total value of imports until 2018, when the total value stood at 3.9 billion dollars. Based on the value of imports, it can be estimated that around 16 million e-readers were sold in 2018, down from over 20 million at the peak in 2014.

Figure 52: E-readers imports into the European Union[109]



Source: *Comtrade (2019).*
Note: *TARIC code 8543700500; Reporter: EU-28; partner: All the world. Units were estimated based on value of imports derived from Comtrade and average retail price in USD of e-readers sold on www.Amazon.co.uk on 30 October 2019, under the assumption that the exchange rate and the average price of a typical e-reader did not change in the period of time considered.*

[108] Vrethager (2017). *The future of the book industry, digital or physical? Case Study: Amazon*. Accessed at: https://www.theseus.fi/bitstream/handle/10024/136159/Vrethager_Robin.pdf?sequence=1&isAllowed=y on 17 September 2019.

[109] The product code used (847130) includes also other devices alongside e-readers.

Wearables

Product characteristics

Description of the product

Wearables, or wearable technology, are terms used to identify a set of devices such as smartwatches, smart glasses, or headphones that can be worn on the body and offer a variety of different functionalities depending on the type of device.

Charging characteristics of the product

Among the sample of 15 wearables analysed, including earpods, smartwatches, and smart glasses, it was found that the minimum charging current is 0.1A and the minimum voltage is 3.7V (total of 0.7W). The maximum current is 2A and the voltage 9V (total of 10W).

All the 15 wearables analysed were sold together with a charging cable, but 8 were sold without an EPS. 6 of the 15 wearable devices in the sample, in fact, have proprietary connectors (including one that has Lighting). The remaining devices have either USB micro B connectors (7 devices), USB Type C (1), and 1 device is charged using wireless technology.

Table 41: Comparison of charging characteristics between wearables and smartphones

	Current		Voltage		Power	
	Max	Min	Max	Min	Max	Min
Wearables	2A	0.1A	9V	3.7V	10W	0.7W
Smartphones	2.5A	1A	12V	5V	18W	5W

Source: *Ipsos's own research (2019) based on a sample of 15 wearables.*

Market characteristics

Data sources

Data on wearables is obtained from a selection of press releases dealing with forecasted worldwide shipments for the years 2017-2022 published by Gartner, a consultancy and market research firm specialised in the digital sector. Additional data for the period 2015-2018 was sourced from Statista.

Official data on imports of smartwatches into the EU is obtained from Comtrade. However, the product code used to analyse the smartwatch market also contains data on digital watches, and no further distinction is possible. In addition to this, data from Comtrade is only available for smartwatches, as there are no TARIC codes for other types of wearables.

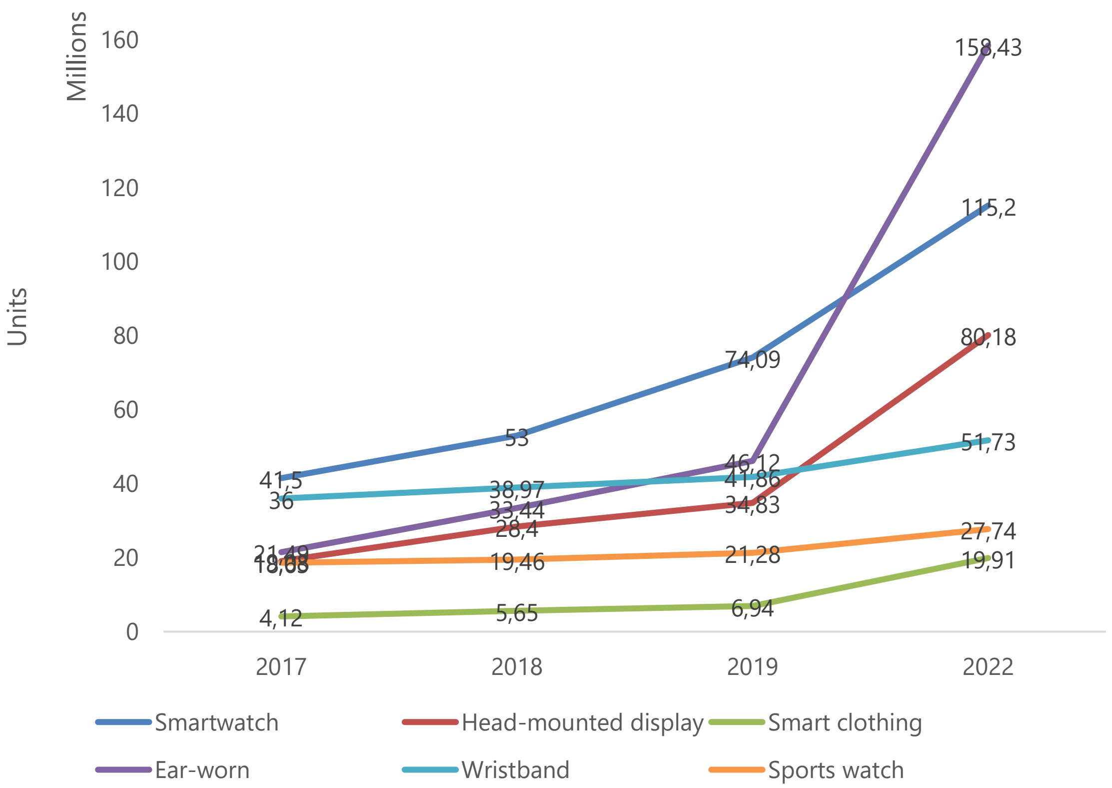
Location of manufacturers

Manufacturers of wearable technologies are mainly headquartered in the United States and in Asia. One manufacturer of wearable sport equipment, Polar Electro, is located in Finland.

Data on market trends

Forecast data released by Gartner reported in Figure 53 shows generalised upward trends for shipments of wearable devices between 2017 and 2022. Smartwatches were the leading segment of the market between 2017 and 2019, with 41.5 million and 74 million of items shipped in the two years respectively. However, shipments of earpods and similar technologies which, according to forecasts, totalled 18.6 million units shipped in 2017 and reached 46.1 million units in 2019, were expected to surge and reach 158.4 million of units in 2022 globally. Twenty million units of virtual-reality headset were forecasted to be sold in 2017, increasing to 34.8 million in 2019, and 80.1 million in 2022. More modest shipment grow was recorded for sport watches; units shipped worldwide were forecasted at 18.6 million in 2017, 21.3 million in 2019, and 27.7 million in 2022. Smart clothing, expected to have sold 4.1 units in 2017, then 6.9 units in 2019, and 19.9 million units in 2022.

Figure 53: Wearables worldwide shipments

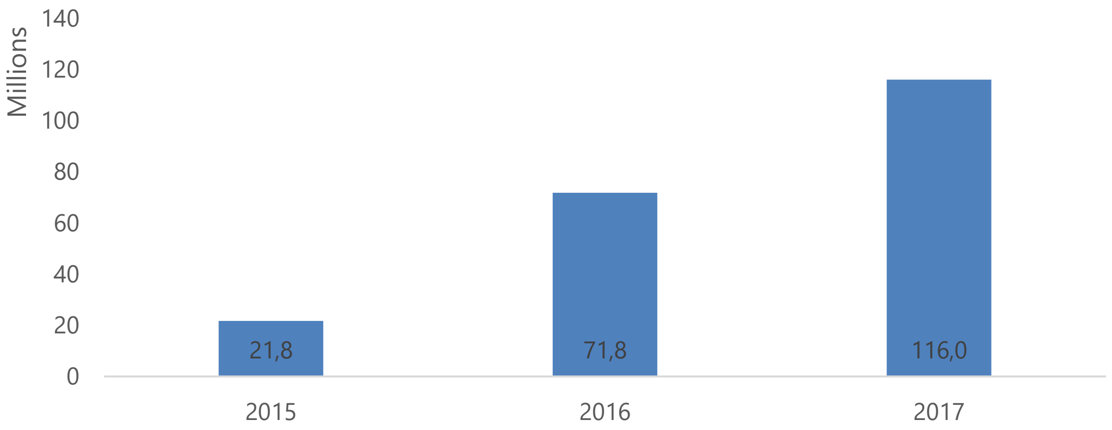


Source: *Gartner (2018)*[110]*.*
Note: *Data for 2019 and 2022 is forecast.*

Statista provides data on wearables popularity in Europe. The three-year period between 205 and 2017 illustrated in Figure 54 exhibits a clear upward trend, with sales rapidly increasing from 21.8 million units in 2015 to 116 million units in 2017.

[110] Gartner (2018). *Gartner Says Worldwide Wearable Device Sales to Grow 26 Percent in 2019*. Accessed at: https://www.gartner.com/en/newsroom/press-releases/2018-11-29-gartner-says-worldwide-wearable-device-sales-to-grow- on 17 September 2019.

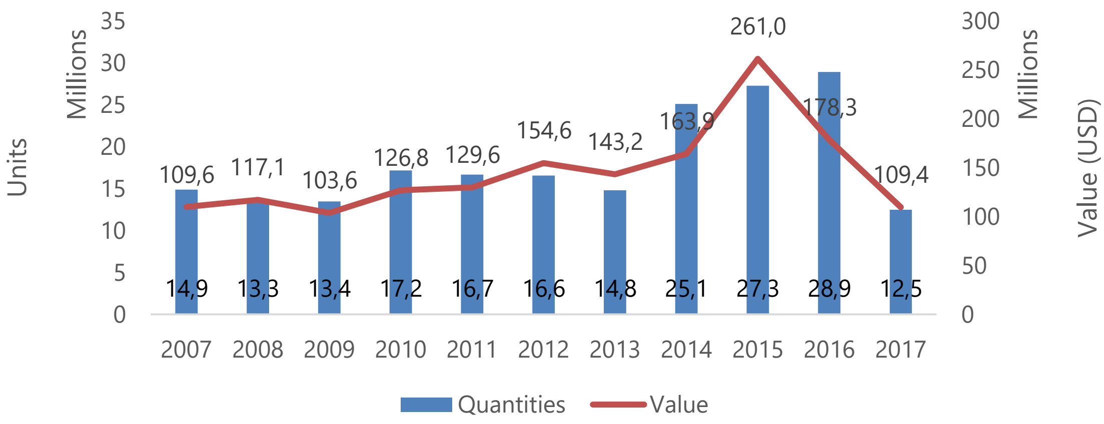
Figure 54: Number of wearable devices in Europe



Source: *Statista (2019)*[111].

Data from Comtrade in Figure 55 illustrates that imported quantities of smartwatches (together with digital watches) grew considerably between 2013 and 2016, reaching 28.8 million units. The value of imports peaked in 2015, at 261 million dollars, and then dropped to 109 million dollars in 2017, the latest available year.

Figure 55: Smartwatch imports into the European Union[112]



Source: *Comtrade (2019).*
Note: *TARIC code 9102120000; Reporter: EU-28; partner: All the world.*

[111] Statista (2019). *Number of connected wearable devices worldwide by region from 2015 to 2022*. Accessed at: https://www.statista.com/statistics/490231/wearable-devices-worldwide-by-region/ on 11 November 2019.

[112] The product code used also includes normal watches.

Digital cameras

Product characteristics

Description of the product

Digital cameras are devices that normally have built-in lenses and allow to take photos and videos with either automatic or adjustable settings. The two main types of cameras are compact cameras and DSLR cameras. Compact cameras (or point-and-shoot cameras) have fixed lenses and basic functions. DSLR (digital single-lens reflex) cameras have interchangeable lenses and offer more advanced features. Another type of cameras are sport cameras (or action cameras), which are dealt with in a separate section.

Charging characteristics of the product

Among the 12 digital cameras included in the analysis, the lowest current needed by a device to charge was 0.2A and the voltage was 3.6V (for a total of 1W), whereas the highest current was 1.89A and the voltage 8.4V (total of 10W).

For all those cameras in the sample for which information was found (11 out of 12), the box included both the EPS and the charging cable. 1 of the cameras had a USB Type C connector, 2 had a proprietary connector, and the remaining 9 cameras had a USB micro B connector.

Table 42: Comparison of charging characteristics between digital cameras and smartphones

	Current		Voltage		Power	
	Max	Min	Max	Min	Max	Min
Digital cameras	1.89A	0.2A	8.4V	3.6V	10W	1W
Smartphones	2.5A	1A	12V	5V	18W	5W

Source: *Ipsos's own research (2019) based on a sample of 12 digital cameras.*

Market characteristics

Data sources

One source of data at the global and European level are the reports released by the Camera & Imaging Products Association (CIPA), an association of manufacturers of digital cameras based in Japan that represents some of the most prominent Japanese camera manufacturers (including Canon, Casio, Nikon, Panasonic, Ricoh, Sony) and is supported by other international companies (such as Apple, Huawei, and Samsung Electronics).

In addition to this, Comtrade data is used to analyse import quantities into the European Union.

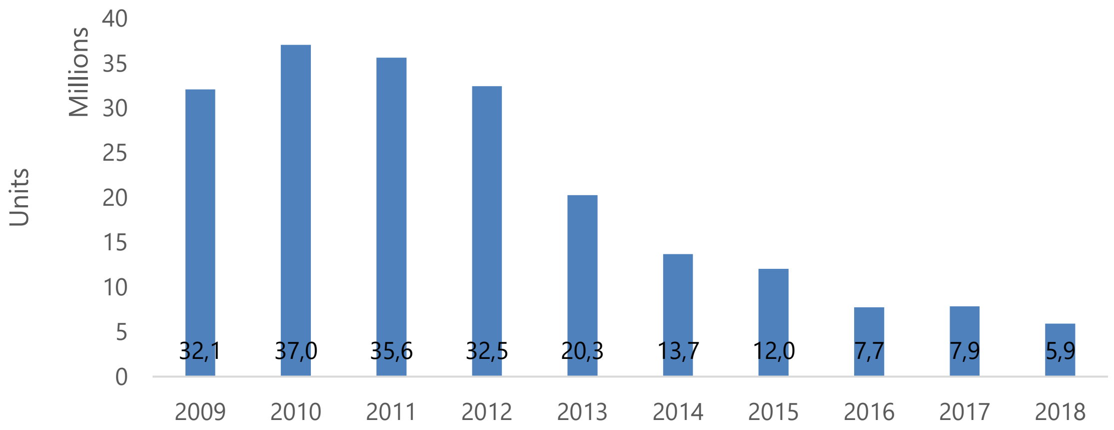
Location of manufacturers

Most manufacturers of digital cameras have their headquarters in Asia (China, Japan, South Korea, Taiwan) and in the United States. Two digital camera manufacturers (Leica, Medion) are based in Germany.

Data on market trends

According to annual data released by CIPA based on information provided by its members, compact digital camera shipments towards Europe declined starting from 2010, until they reached 37 million, to 5.9 million in 2018, as shown in Figure 56.

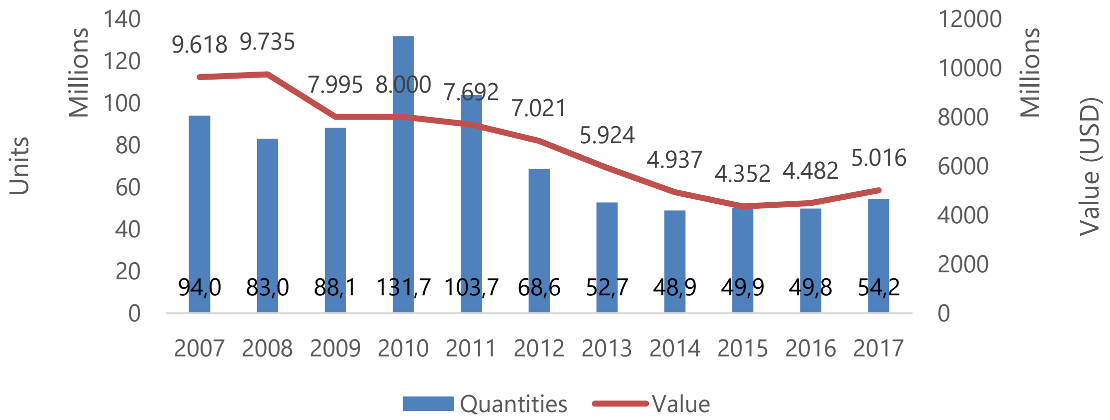
Figure 56: Digital camera (fixed-lens) shipments to Europe



Source: *CIPA (2019)*[113]

The decline shown by CIPA's figures is consistent with import data released by Comtrade in Figure 57. Import quantities into the European Union reached their highest point in 2010, at 131.7 million units, and declined to less than half in the following years, standing at 54.2 million units in 2017. The total value of imports fell from 8 billion dollars in 2010 to 5 billion dollars in 2017.

Figure 57: Digital camera imports into the European Union



Source: *Comtrade (2019).*
Note: *TARIC code 8525803000; Reporter: EU-28; partner: All the world.*

[113] CIPA (2019*). Digital cameras – Statistical data*. Accessed at: http://www.cipa.jp/stats/dc_e.html on 19 September 2019.

Sport cameras

Product characteristics

Description of the product

Sport cameras, also known as action cameras, are small cameras that can be attached to a person's body or to sport equipment (e.g. to a bike, a motorbike, or a helmet), allowing to film or take photos hands-free by using automatic settings. Certain action cameras can be used also in extreme conditions (e.g. underwater).

Charging characteristics of the product

In a review of 12 action cameras conducted for this study, the minimum current required was 1A and the minimum voltage was 3.6V. The maximum current was 2A and the maximum voltage was 5V. The total power required ranged between 1.3W and 10W.

8 out of 12 action cameras in the sample were sold with a charging cable, but without EPS. 5 utilised USB micro B connectors, 4 USB Type C, and 3 USB mini B.

Table 43: Comparison of charging characteristics between sport cameras and smartphones

	Current		Voltage		Power	
	Max	Min	Max	Min	Max	Min
Sport cameras	3.25A	1A	20V	3.9V	65W	2.4W
Smartphones	2.5A	1A	12V	5V	18W	5W

Source: *Ipsos's own research (2019) based on a sample of 12 sport cameras.*

Market characteristics

Data sources

Data for Western Europe is available from Statista, although it only covers the period 2015-2017 with the last two years as forecast.

Comtrade reports statistics related to cameras that can be used for aerial filming on drones, underwater, or other similar uses. It can be assumed that most of the products in this category are sports cameras. No other more specific source was found.

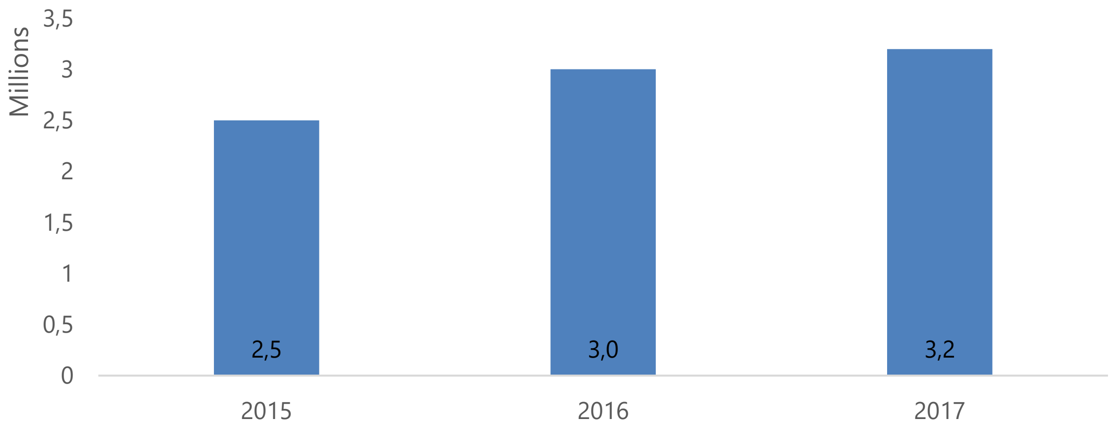
Location of manufacturers

Manufacturers of sport cameras have their headquarters mainly in Asia or in the United States. No European manufacturers of action cameras were found.

Data on market trends

Data from Statista shows a growing market for sport cameras. It is estimated that in 2015 2.5 million sport cameras were sold in Western Europe; in 2017, forecast data suggests that 3.2 million sport cameras have been sold, as illustrated in Figure 58.

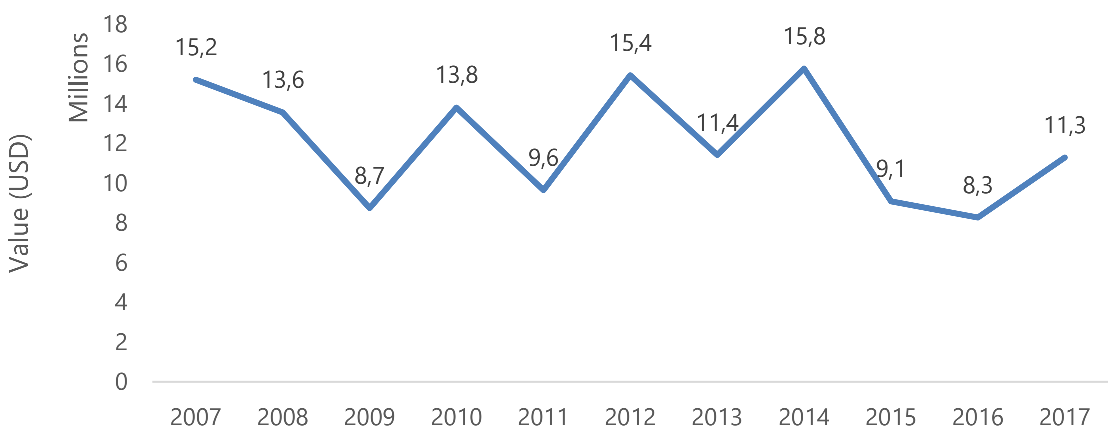
Figure 58: Sport camera sales in Western Europe



Source: *Statista (2019)[114].*
Note: *Data for 2016 and 2017 is forecast.*

Figure 59 shows that in 2008 the total value of shipments stood at USD 13.6 million, reaching a peak in in 2014, at USD 15.8 million, and touching the sum of USD 11.3 million in 2017. While import quantities in 2017 were only 4% of the quantity of cameras imported in 2008, the total value of imports was 83% of the value in 2008.

Figure 59: Sport camera imports into the European Union[115]



Source: *Comtrade (2019).*
Note: *TARIC code 9006300000; Reporter: EU-28; partner: All the world.*

[114] Statista (2019). *Number of action cam sales in Western Europe from 2014 to 2017*. Accessed at: https://www.statista.com/statistics/677288/number-of-action-cam-sales-in-western-europe/ on 11 November 2019.

[115] Import quantities for 2013 not available.

Videogame devices

Product characteristics

Description of the product

Videogames consoles, accessories, and controllers comprise a series of battery-operated, handheld devices which are utilised to play videogames.

Charging characteristics of the product

In a sample of 8 controllers, virtual reality headsets, and console devices reviewed for this study, the current ranges between 0.8A and 3A, whilst the voltage spans 3.65V to 15V (total power between 3W and 20W).

When information about decoupling was available (6 out of 8 devices), it was found that all the videogame consoles and controllers were sold with both EPS and cable. USB micro B was the main type of connector, with only one device using USB Type C and one device using USB mini B.

Table 44: Comparison of charging characteristics between videogame devices and smartphones

	Current		Voltage		Power	
	Max	Min	Max	Min	Max	Min
Videogame devices	3A	0.8A	15V	3.65V	20W	3W
Smartphones	2.5A	1A	12V	5V	18W	5W

Source: *Ipsos's own research (2019) based on a sample of 8 videogame devices.*

Market characteristics

Data sources

The first data source used to inform market trends at the global level is derived from Nintendo's publicly available information on total shipments of their own devices worldwide. Although this offers only a partial view of the global market for videogame consoles, Nintendo is one of the major producers of videogames in the world, with an estimated 22% market share in 2017[116].

For the European Union, market trends for quantity and value of imports are derived from Comtrade statistics.

Location of manufacturers

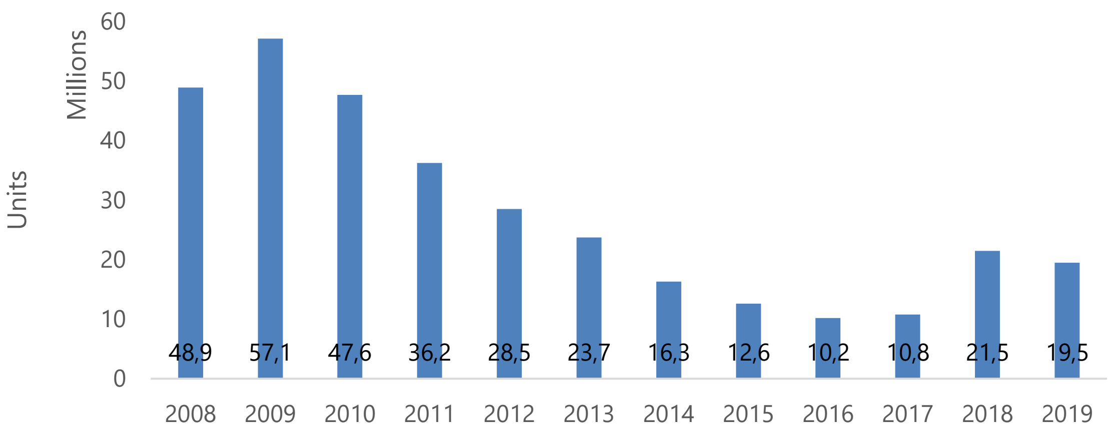
No European manufacturers of videogame consoles or controllers were found. Producers are mainly based in Asia (Japan) and in the United States.

[116] CNBC (2018). *Games console market has had its best year since 2011 thanks to Nintendo's 'record-breaking comeback'*. Accessed at: https://www.cnbc.com/2018/03/07/nintendo-comeback-sees-games-console-market-have-best-year-since-2011.html on 10 September 2019.

Data on market trends

Nintendo data in Figure 60 shows that global shipments peaked around 2009, at 57 million unit sold. After 2015, the trend was downwards, but shipments bounced back in 2017, with 10.8 million units shipped worldwide. In 2018, shipments reached 21.4 million units, and decreased slightly in 2019, at 19.5 million.

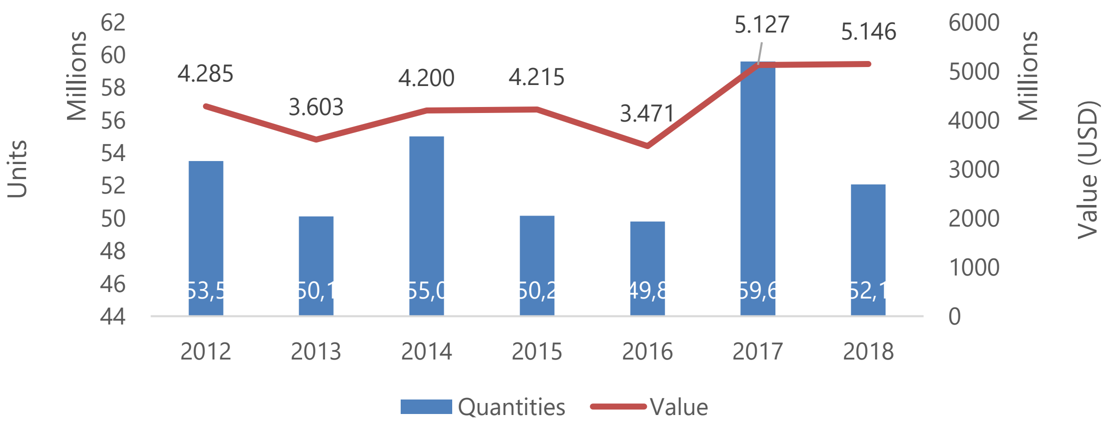
Figure 60: Nintendo worldwide shipments[117]



Source: *Nintendo (2019)[118].*

Data from Comtrade presented in Figure 61 shows an irregular pattern when considering import quantities into the European Union. After an increase in imported units in 2014 when videogame consoles imported reached 55 million units, and lower imports in 2015 and 2016, imports reached a peak in 2017 with 59 million units imported into the EU, for a total value of 5 billion.

Figure 61: Videogame consoles imports into the European Union



Source: *Comtrade (2019).*
Note: *TARIC code 9504500000; Reporter: EU-28; partner: All the world.*

[117] Figures for 2019 until June.

[118] Nintendo (2019). *Historical Data. Consolidated Sales Transition by Region.* Accessed at: https://www.nintendo.co.jp/ir/en/finance/historical_data/index.html on 17 September 2019.

Laptops

Product characteristics

Description of the product

A laptop computer (often referred to also as 'notebook') is a portable computer built in a clamshell comprising a screen, keyboard, trackpad, and generally also speakers, a microphone, a webcam, and various types of connectors. In addition to this, older laptops also included optical disc drivers capable of playing CDs and DVDs.

Charging characteristics of the product

Based on a review of a sample of 11 popular laptops from various brands, we have observed that they require charge at between 1.5 and 3.25A of current, and a voltage of 19-20V, providing between a minimum of 30W and a maximum of 65W..

All the laptops in the sample analysed were sold with both the EPS and the charging cable in the box. 8 out of 11 laptops had proprietary connectors, whilst 3 had USB Type C connectors.

Table 45: Comparison of charging characteristics between laptops and smartphones

	Current		Voltage		Power	
	Max	Min	Max	Min	Max	Min
Laptops	3.25A	1.5A	20V	19V	65W	30W
Smartphones	2.5A	1A	12V	5V	18W	5W

Source: *Ipsos's own research (2019) based on a sample of 11 laptops.*

Market characteristics

Data sources

Data is obtained from Comtrade official statistics describing imports of portable computers into the European Union.

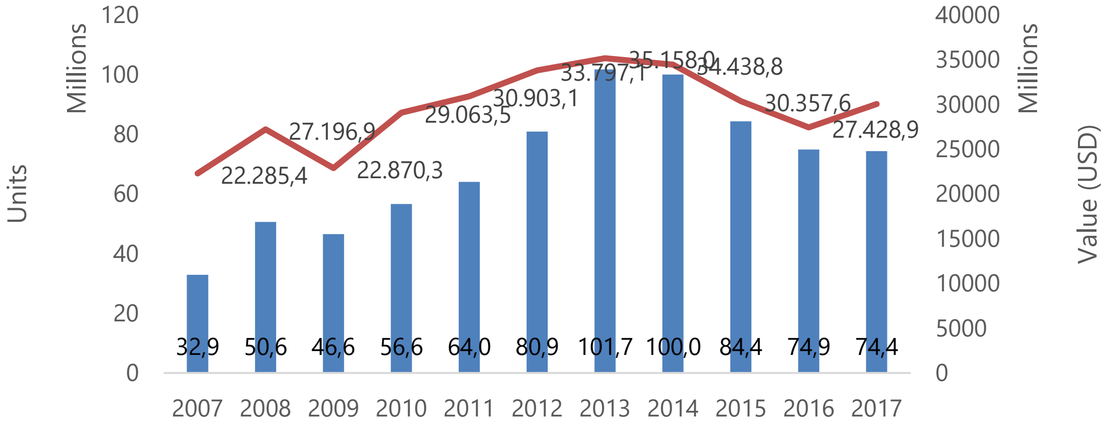
Location of manufacturers

Laptop manufacturers are mainly located in Asia and in the United States. In the European Union, there are two manufacturers headquartered in Germany: Medion and Terra Home Wortmann.

Data on market trends

Comtrade data presented in Figure 62 shows that sales of laptops increased between from 46.6 million units imported in 2009 to 101.7 million units in 2013. Imports slightly decreased in 2014 throughout 2017, when they stood at 74.4 million units. The total value of laptop imports generally followed the same pattern, peaking at over 35 billion dollars in 2014, and then dropping to 27.4 billion dollars in 2017.

Figure 62: Laptop imports into the European Union



Source: *Comtrade (2019).*
Note: *TARIC code 8471300000; Reporter: EU-28; partner: All the world.*

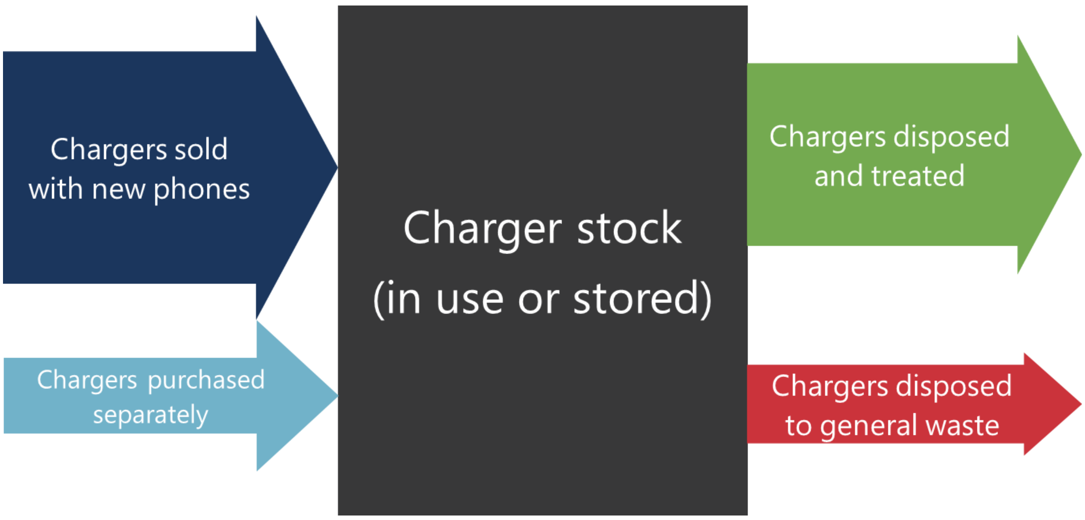
Annex E: Stock Model - Methodological Annex

This methodological annex provides more detail on the calculations and assumptions behind the stock model used to model the evolution of the charger market, the environmental impacts and the impacts on consumer and producer cost.

Approach

The overall approach of the stock model is based on additions and disposals of chargers each year. Modelling the four flows into or out of the stock of chargers in use or stored as summarised below.

Figure 63: Flows of chargers modelled



Additions

The additions to the stock model were modelled from 2008 onwards.

For chargers sold with new phones it was assumed that a charger was provided with all new phones sold since 2008. Sales data was based on:

- 2013-2018 on the industry leading database of sales from IDC, data purchased specifically for this project. IDC values were increased by 1.6% to represent that data for EE, LT, LV and SI were missing from the total, and these represent 1.6% of the EU28 population.
- Pre-2013 sales were estimated on the basis of PRODCOM data (26302200 - Telephones for cellular networks or for other wireless networks), which records units sold. IDC values for 2013-2018 were on average 92.3% of the PRODCOM value. This was assessed as close enough to act as a proxy and therefore this ratio (92.3%) was applied to PRODCOM values in earlier years.
- Values from 2018 were held constant from 2019-2028.

For chargers purchased separately no data was available directly. An estimate of these sales was made on the basis of the consumer survey. This noted that 16.8% of all chargers in use were purchased separately. An equivalent number were therefore added to annual sales.

Table 46: Charger additions to model: Baseline scenario

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Mobile phone sales [million units]	261.2	240.4	227.2	186.7	194.2	191.9	189.4	189.4	175.7	165.3	158.2	158.2	158.2	158.2	158.2	158.2	158.2	158.2	158.2	158.2	158.2
Chargers sold separately [million units]	52.7	48.5	45.9	37.7	39.2	38.7	38.2	38.2	35.5	33.4	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
Total chargers added [million units]	314.0	289.0	273.0	224.3	233.4	230.6	227.6	227.7	211.1	198.7	190.2	190.2	190.2	190.2	190.2	190.2	190.2	190.2	190.2	190.2	190.2

Table 47: Disposal ratios

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Disposals to waste treatment	64%	65%	66%	67%	68%	69%	70%	71%	72%	73%	74%	75%	76%	77%	78%	79%	80%	81%	82%	83%	84%
Incorrect disposals	36%	35%	34%	33%	32%	31%	30%	29%	28%	27%	26%	25%	24%	23%	22%	21%	20%	19%	18%	17%	16%

The types of chargers added were split by EPS and cable types. The following types were modelled.

Main component	Type
EPS -USB A	USB A - Standard charger
EPS -USB A	USB A - Fast charger - USB-PD
EPS -USB A	USB A - Fast charger - QuickCharge
EPS - USB C	USB C - Standard charger
EPS - USB C	USB C - Fast charger - USB-PD
EPS - USB C	USB C - Fast charger - QuickCharge
Cables (1m)	USB A - USB Micro B
Cables (1m)	USB A - USB C
Cables (1m)	USB A - proprietary
Cables (1m)	All-in-one - USB Micro B
Cables (1m)	USB C - USB Micro B
Cables (1m)	USB C - USB C
Cables (1m)	USB C - proprietary
Cables (1m)	All-in-one - USB C
Adapter	Adapter USB Micro B - USB C
Adapter	Adapter Proprietary - USB Micro B
Adapter	Adapter Proprietary - USB C
Adapter	Adapter USB A-USB C

In the baseline, historic additions were split on the basis of:

- All of the Apple market share used a standard EPS USB A provided with a USB A – proprietary cable.
- Prior to 2016 all other chargers were assumed to be EPS USB A provided with a USB A – USB Micro B cable.
- From 2016 both fast charging EPS (using USB A connectors) and USB C connectors first started to appear. These were included in the model on the basis of IDC data.

Between 2019-2021 all options were modelled with the same developments, namely:

- The 2018 Apple market share of 21.4% was held constant until 2028.
- Continued growth in fast charging EPS, converging on the USB PD standard, around 70% fast charging by 2021, split equally between EPS USB A and C
- Continued decline in USB A – USB Micro B cables, to 12.5% by 2021, these being replaced by:
  - USB A – USB C cables, 41% in 2021
  - USB C to USB C cables, 25% in 2021
- Migration of Apple from EPS USB A with USB A – Proprietary cable, to EPS USB C with USB C – Proprietary cable, 12.5% of 21.4% by 2021.

With the expected introduction of the policy options in 2023 then adjustments in producer behaviour were modelled to begin already in 2022. These varied by policy option, but are summarised in Table 48 below.

Table 48: Modelled developments in charger stock from 2022 -2028

		Connectors at the device end			EPS	
Policy options	**Baseline**	1. USB Type-C only	2. USB Type-C only; for phones with proprietary receptacles, adaptors in the box compulsory	3. USB Type-C or proprietary; for cables with proprietary connectors, adaptors in the box compulsory	4. Guaranteed interoperability of EPS	5. Interoperability plus minimum power requirements for EPS
Changes in assump-tions compared to the baseline scenario	USB A – USB Micro B market share drops to 0% by 2022 Apple completes switch to EPS USB C and fast charging as standard by 2022. Fast charging EPS USB C gains market share, growing to 90% of entire market by 2024. Remaining 10% of market assumed to cater for low-end phones that do not need fast charging. These chargers are all USB C (device side) and split between EPS USB A and USB C, converging fully on EPS USB C by 2025.	Assumes proprietary connectors are phased out in new phones from 2022, to zero by 2023, switching to USB C Reduction in standalone charger market based on difference in purchasing of standalone chargers between Apple and non-Apple users. Consumer survey shows Apple users 16% more likely to purchase standalone chargers. In this option standalone sales of proprietary charger share (21.4%) reduced by 16%, resulting in 3.4% fewer standalone charger sales overall.	Assumes proprietary connectors are phased out from 2022, to zero by 2023, switching to USB C Assumes that from 2023 an adaptor from USB C cable (device side) to proprietary is provided in same proportions to Apple market share (21.4%) Same impact on standalone market at option 1, resulting in 3.4% fewer standalone sales	Assumes that from 2023 adaptors from proprietary cable connectors to USB C (device side) are provided Assumes no impact on standalone market as Apple users will still purchase replacement proprietary chargers	No difference is modelled due to insufficient data on current standard compliance A reduction in standalone sales of 2.5% is assumed.[119] This reflects possible reduction in purchases of chargers to address incompatibility issues. Currently assumed to be very low, as >90% of EPS believed to be interoperable.	This option results in the 10% residual of non-fast chargers sold with phones in the baseline being reduced to zero by 2023.The reduction in standalone sales from option 4 of 2.5% is included. In addition a further 2.5% reduction is assumed as those that purchase a charger for faster charging no longer need to purchase an additional charger[120].

[119] This assumption is made based on our experience in this work, from which we would estimate that incompatibility of the type this option addresses affects less than 10% of chargers. Common charging standards would address a large part of the incompatibility that exists, reducing the need for standalone charger purchases. But with a lack of supporting data on which this assumption rests, the 2.5% reduction in standalone charger sales should be treated cautiously. A similar effect could be foreseen for options 2 & 3 with the use of the adaptors.

[120] In the consumer survey Q C2b 7.9% of consumers answered that they purchased a standalone charger to get fast-charging capabilities. As fast-charging is modelled to become the effective standard over the next 5 years, then the full 7.9% rate is assessed to not be a realistic assumption.

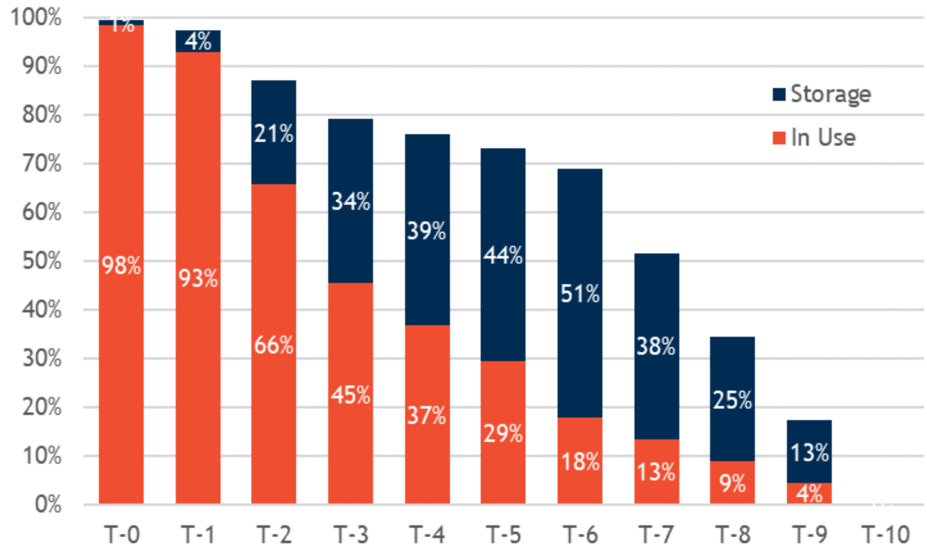
Standalone charger sales followed the same patterns with a 1-year time lag (T-1).

Disposals and treatment

Removals of chargers from the stock is modelled over a period of 10 years from the addition of a charger. The model assumes that after 10 years all chargers have been disposed of.

As explained in the main report, disposals are modelled in 2 ways, firstly at the decision point of purchasing a new phone, secondly, following a period of 6 years the remaining stock of chargers is linearly reduced. Over the first six years a proportion of chargers is modelled to be stored, as at the point of buying a new phone consumers choose not to dispose of the charger by giving it away, selling it or throwing it away, but to store it (e.g. the charger is kept at home, and may be used occasionally, but is not the primary charger in use). The proportions for this assumption were based on the consumer survey. The trend is summarised below.

Figure 64: Removals of chargers from the stock over time



This disposal profile is applied to each set of annual additions.

Disposals out of the stock (use and storage) are modelled as sent to treatment or incorrect disposal. Sent to treatment covers chargers disposed of to WEEE streams where they may be recovered, re-used or recycled. Incorrect disposal means that the chargers are thrown into general waste and then most likely sent to landfill or incinerated. As described in the main report, the proportions assumed for treatment are based on analysis and reporting of the implementation of the WEEE Directive and also feedback from consumers in the consumer survey. A 1 percentage point increment is applied each year, starting from a 75:25 split in 2019, as shown previously in Table 47.

Charger profiles

The additions and disposals provide for the calculation of the quantity of each type of charger component in the stock in a given year. The impact associated with these chargers is calculated via the use of charger profiles which designate key characteristics for each charger component type. The key characteristics of each charger component, as modelled, are presented below in Table 49.

These characteristics were selected / calculated on the basis of the following:

- Production, wholesale and retail prices – on the basis of scans of websites stocking such materials and feedback from manufacturers in the targeted survey.

- Weight – through weighing of a variety of actual charger components and technical information from retailer and manufacturer websites.

- Composition – on the basis of the LCIA studies analysed in section 3.6 of the main report.

- CO_2 emissions – from averaged emission factors per g weight, per component type on the basis of the LCIA studies analysed in section 3.6.

Table 49: Charger characteristics used in stock model

Main component	Type	Production cost [€]	Wholesale price [€]	Retail price [€]	Weight [g]	Of which - Plastic [g]	Of which - Copper [g]	Of which - other [g]	CO_2 emissions [kg CO2e/unit]
EPS -USB A	USB A - Standard charger	1.2	1.5	6.0	32.2	16.7	0.4	15.1	2.30
EPS -USB A	USB A - Fast charger - USB-PD	2.3	4	10.0	67.4	34.9	0.8	31.6	4.82
EPS -USB A	USB A - Fast charger - QuickCharge	3	3.5	9.0	48.4	25.1	0.6	22.7	3.46
EPS - USB C	USB C - Standard charger	2.5	6	11.0	35.0	18.1	0.4	16.4	2.50
EPS - USB C	USB C - Fast charger - USB-PD	4	8	15.0	56.3	29.2	0.7	26.4	4.03
EPS - USB C	USB C - Fast charger - QuickCharge	4	8	15.0	52.0	27.0	0.6	24.4	3.72
Cables (1m)	USB A - USB Micro B	0.4	0.5	2.0	17.6	8.8	2.8	6.0	0.53
Cables (1m)	USB A - USB C	0.75	0.9	3.0	25.0	12.5	3.9	8.6	0.75
Cables (1m)	USB A - proprietary	0.6	0.7	25.0	15.8	7.9	2.5	5.4	0.48
Cables (1m)	USB C - USB C	1.2	1.5	8.0	25.0	12.5	3.9	8.6	0.75
Cables (1m)	USB C - proprietary	1.2	1.7	25.0	20.4	10.2	3.2	7.0	0.62
Adapter	Adapter USB Micro B - USB C	0.5	0.5	7	2	1.0	0.0	1.0	0.06
Adapter	Adapter Proprietary - USB Micro B	0.5	0.5	25	2	1.0	0.0	1.0	0.06
Adapter	Adapter Proprietary - USB C	0.5	0.5	25	2	1.0	0.0	1.0	0.06
Adapter	Adapter USB A-USB C	0.5	0.5	4	2	1.0	0.0	1.0	0.06

Other assumptions made to estimate economic impacts

Actual production costs and prices are valuable information and can vary considerably by supplier and brand. We have used the best information available, but uncertainties remain. The economic impacts calculated could vary considerably if different margins per product (costs and prices) are used.

Production costs for the different charging solutions (EPS and cables) have been kept constant over time. However, there are two effects that may modify real prices:

- Some of the technologies (e.g. USB Type C) are new, and prices are expected to reduce as they become more mainstream. Our model, therefore, may overestimate the costs of new solutions.
- Reduction in demand may produce an increase in marginal cost due to fixed factor problems. Therefore, the scenario with high decoupling rates may be underestimating costs and prices.

It is unknown which of these effects would be stronger, i.e. whether both effects would offset each other, whether the net effect would increase final price/cost, or whether the net effect would decrease final price/cost, and if so, at what rate. Given these uncertainties, price and cost of all products have been kept constant over time.

Calculations

The key impact calculations made in the model are as follows:

- Material usage: Charger additions per charger type * charger profile material composition per material type (plastics, copper, other)
- E-waste generation: Sum of charger disposals in that year, distributed from previous years on the basis of Figure 64 above * sum of charger profile material composition (plastics, copper, other)
- Waste treatment: E-waste generation * disposal profile for that year (see disposal ratios in Table 47)
- CO_2 emissions: Charger additions per charger type * charger profile GHG emissions per charger type
- Consumer cost: (Charger-in-the-box additions per type * wholesale cost per type) plus (standalone sales per type * retail price)
- Producer benefit: Consumer cost less (total additions * production cost)

The comparisons with the baseline are calculated as follows:

1. We calculated the impacts per year (2023-2028) and per policy option following the formulae indicated above.
2. For values expressed in monetary terms (economic impacts), we calculated the net present value of the impacts per year, using as base year 2020 and a discount rate of 4%, as per the Better Regulation Guidelines.
3. We compared the total impacts for the period 2023 to 2028 for each policy option, and compared them against the baseline. For values expressed in monetary terms, we compared the net present value.

The calculation of impacts for decoupling scenarios followed the same process described above. We used the same prices and characteristic of chargers, and we modelled three different decoupling scenarios for the baseline, as explained above. These scenarios in our stock model provided the quantities to estimate the impacts against the baseline.

Examples of calculations

Example 1: Economic costs

For illustration, we present below the costs for consumers and the industry per year in the baseline and policy option 1. For completeness, we present costs in 2020 (base year) and 2023 to 2028.

Table 50: Estimated economic impact per year for consumers and the industry in the baseline

	2020	2023	2024	2025	2026	2027	2028
Consumers							
Consumer cost - Total (million EUR)	1,142	1,975	2,125	2,274	2,317	2,317	2,317
Consumer cost - Avg. Unit (EUR)	6.0	10.4	11.2	12.0	12.2	12.2	12.2
	PV	1,747	1,805	1,854	1,814	1,741	1,672
Industry - (consumer cost - production cost)							
Producer cost - Total (million EUR)	629	1,135	1,227	1,322	1,357	1,357	1,357
Producer cost - Avg. Unit (EUR)	3.3	6.0	6.5	7.0	7.1	7.1	7.1
	PV	1,004	1,042	1,078	1,062	1,019	979

Table 51: Estimated economic impact per year for consumers and industry in policy option 1

	2020	2023	2024	2025	2026	2027	2028
Consumers							
Consumer cost - Total (million EUR)	1,142	1,858	1,980	2,127	2,169	2,169	2,169
Consumer cost - Avg. Unit (EUR)	6.0	9.8	10.5	11.2	11.5	11.5	11.5
	PV	1,643	1,682	1,735	1,698	1,630	1,565
Industry		1	2	3	4	5	6
Producer cost - Total (million EUR)	629	1,022	1,087	1,181	1,214	1,214	1,214
Producer cost - Avg. Unit (EUR)	3.3	5.4	5.7	6.2	6.4	6.4	6.4
	PV	904	924	963	950	912	876

The sum of the net present value per year provides the total net present value for the period 2023-2028, which is presented below for both the baseline and policy option 1.

Table 52: Comparison of impact between policy option 1 and baseline for the period 2023-2028.

		Baseline	Option 1
Cost to Consumers [NPV million EUR]	Total 2023-2028	10,632	9,952
	Difference with baseline		-680

		Baseline	Option 1
	Annual average	1,772	1,659
	Difference with baseline		-113
	As %		-6.4%
Of which:			
Benefit for Producers [NPV million EUR]	Total 2023-2028	6,184	5,529
	Difference with baseline		-655
	Annual average	1,031	922
	Difference with baseline		-109
	As %		-10.6%

Example 2: Material usage

2018 charger additions, based on sales of 158.2 million with new phones and 32.0 million standalone sales.

EPS	Cable	Split	Units	Weight per component [g]	Material consumption [tonnes]
EPS -USB A	USB A - Standard charger	73.5%	139 743 152	32.2	4 493
EPS -USB A	USB A - Fast charger - USB-PD	9.5%	18 069 542	67.4	1 218
EPS -USB A	USB A - Fast charger - QuickCharge	17.0%	32 390 930	48.4	1 566
EPS - USB C	USB C - Standard charger	0%	0	35.0	0
EPS - USB C	USB C - Fast charger - USB-PD	0%	0	56.3	0
EPS - USB C	USB C - Fast charger - QuickCharge	0%	0	52.0	0
Cables (1m)	USB A - USB Micro B	51.9%	98 753 985	17.6	1 738
Cables (1m)	USB A - USB C	26.5%	50 460 472	25.0	1 262
Cables (1m)	USB A - proprietary	21.6%	40 989 167	15.8	648
Cables (1m)	All-in-one - USB Micro B	0%	0	14.0	0
Cables (1m)	USB C - USB Micro B	0%	0	21.3	0
Cables (1m)	USB C - USB C	0%	0	25.0	0
Cables (1m)	USB C - proprietary	0%	0	20.4	0
Cables (1m)	All-in-one - USB C	0%	0	16.0	0
	Total				10 924

Example 3: CO_2 emissions

2024 charger additions, baseline scenario based on sales of 158.2 million with new phones and 32.0 million standalone sales.

EPS	Cable	Split	Units	Emissions per component [kgCO2/unit]	GHG emissions [ktCO2e]
EPS -USB A	USB A - Standard charger	3.5%	6 664 735	2.30	15
EPS -USB A	USB A - Fast charger - USB-PD	12.6%	23 919 631	4.82	115
EPS -USB A	USB A - Fast charger - QuickCharge	0.0%	0	3.46	0
EPS - USB C	USB C - Standard charger	6.5%	12 355 627	2.50	31
EPS - USB C	USB C - Fast charger - USB-PD	77.4%	147 263 630	4.03	593
EPS - USB C	USB C - Fast charger - QuickCharge	0.0%	0	3.72	0
Cables (1m)	USB A - USB Micro B	0.0%	0	0.53	0
Cables (1m)	USB A - USB C	16.1%	30 584 366	0.75	23
Cables (1m)	USB A - proprietary	0.0%	0	0.48	0

Cables (1m)	All-in-one - USB Micro B	0.0%	0	0.42	0
Cables (1m)	USB C - USB Micro B	0.0%	0	0.64	0
Cables (1m)	USB C - USB C	62.5%	118 839 224	0.75	90
Cables (1m)	USB C - proprietary	21.4%	40 780 034	0.62	25
Cables (1m)	All-in-one - USB C	0.0%	0	0.48	0
	Total				0

Sensitivity checks and robustness of the options

The stock model relies on a number of assumptions, but the most influential of these are the assumptions related to the number and type of chargers added to the model each year. Sales of new phones are held constant across all options, as are the proportion of proprietary phones and by extension chargers.

In terms of numbers, the decoupling scenarios give a direct indication of the impact of reduced charger additions each year. With the material use and emissions benefits scaling to around 80% of the charger reductions modelled, e.g. 5% reductions in chargers leading to 4% reductions in materials use and emissions.

The situation is more complex for the options, when variations in the charger types are higher, and where the policy typically mandates changes that are more beneficial for interoperability and other impacts, but that have negative impacts on material use and e-waste. This impact is offset by the effect of any reduction in standalone sales. It is important to note that whilst the assumptions for the reductions in standalone sales are based on evidence from the consumer survey or a logical rationale, these are only best estimates of what may occur. The reality may be quite different. The assumptions for options 4 & 5 are perhaps the most uncertain.

Examining the options we can identify the ‘break-even point’ in standalone sales reduction for the environmental impacts to turn from negative to neutral. For policy option 4, impacts are already positive at the 2.5% reductions, and are neutral compared to the baseline at 0% as no physical change compared to the baseline is modelled.

Policy option	PO1	PO2	PO3	PO4	PO5
Reduction in standalones sales compared to baseline	3.4%	3.4%	0%	2.5%	5%
% reduction required for neutral impact of option on					
- Material consumption	7.3%	10.3%	9.0%	0%	11.0%
- e-waste generation	8.8%	11.6%	6.3%	0%	6.7%
- untreated waste	9.0%	11.8%	6.1%	0%	6.4%
- e-waste treatment	6.9%	10.2%	7.5%	0%	7.4%
-GHG emissions	3.7%	5.3%	4.5%	0%	13.3%

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